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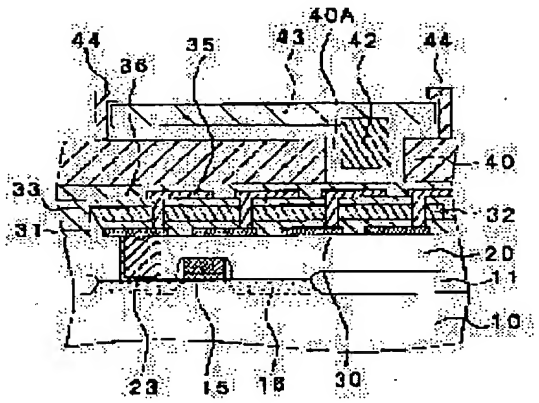
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(54) DIGITAL MICROMIRROR DEVICE

(57)Abstract:
PURPOSE: To provide a digital micromirror device having high reliability and a long life.
CONSTITUTION: The digital micromirror device is constituted by arranging plural sets of micromirror elements constituted of (a) a micromirror part consisting of elements 43, 42, (b) a position control means consisting of elements 30, 32, 35 for controlling the position of the micromirror part provided corresponding to the one micromirror part and (c) transistor elements 15, 16 for controlling the position control means. Then, the micromirror part is attached to the position control means freely movably.



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CLAIMS

[Claim(s)]
[Claim 1] (b) the one micro mirror section and (b) — this — with one position control means for controlling the location of the micro mirror section established corresponding to the one micro mirror section (Ha) one transistor component for controlling this position control means — since — the digital micro mirror device characterized by arranging two or more constituted micro mirror components, and changing, and attaching this micro mirror section free [migration] to a position control means.
[Claim 2] It is the digital micro mirror device according to claim 1 which the micro mirror section is equipped with the permanent magnet, and a position control means consists of an electromagnet, and is characterized by controlling the location of the micro mirror section by electromagnetic force which connects with the transistor component electrically and a position control means generates by control of a transistor component.
[Claim 3] It is the digital micro mirror device according to claim 2 which the united stanchion is prepared in the lower part of the micro mirror section, and this stanchion consists of a permanent magnet, and is characterized by arranging this stanchion near the position control means.
[Claim 4] It is the digital micro mirror device according to claim 2 which the united stanchion is prepared in the lower part of the micro mirror section, and the permanent magnet layer is prepared in the pars basilaris ossis occipitalis at least, and is characterized by the thing of this stanchion for which this stanchion is arranged near the position control means.
[Claim 5] It is the digital micro mirror device according to claim 2 which the united stanchion is prepared in the lower part of the micro mirror section, and the base of this micro mirror section and the external surface of a stanchion are equipped with the permanent magnet layer, and is characterized by arranging this stanchion near the position control means.
[Claim 6] (b) The transistor component formed in the semi-conductor substrate, and the position control means which was established on the insulating layer formed on the (b) this transistor component, and was electrically connected to the transistor component, Consist of a micro mirror body and a stanchion and a micro mirror body is arranged on the guide layer formed on the position control means. (Ha) the micro mirror section by which the stanchion is contained free [migration] by the hole prepared in the guide layer, and the location of a stanchion is controlled by actuation of a position control means — since — the digital micro mirror device characterized by arranging two or more constituted micro mirror components, and changing.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the digital micro mirror device used with image projection equipment.
[0002]
[Description of the Prior Art] In recent years, big screen-ization of television advances with quality improvement of television broadcasting etc., and the television set carrying the big screen Braun tube 29 inches or more is becoming in use. However, while a television set big-screen-izes, the weight increases, for example, AUW is set to 60kg or more in the television set which is 29 inches, and migration is difficult. Although the general broadcast of HDVS is also becoming close, enlargement progresses further and the receiving set using the Braun tube for HDVS has the amount of Oshige of 90kg or more. If it already becomes such weight, it will become very difficult to move the receiving set installed once later.
[0003] On the other hand, the display of a projection method using a liquid crystal device is devised in recent years. In this indicating equipment, in light, it is making a liquid crystal device penetrate, and the image formed on the liquid crystal device is projected on an image screen. In such an indicating equipment, the heavy Braun tube becomes unnecessary, an indicating equipment only consists of the light sources and the liquid crystal devices for lighting, and an indicating equipment becomes very light. It is necessary to make light penetrate the inside of a liquid crystal device in this kind of indicating equipment. it is alike and has the problem that the light transmittance of a liquid crystal device is as low as several %, and the appropriate image projected on the screen is dark.
[0004] In recent years, projection equipment using the digital micro mirror device (Digital Mirror Device) as new projection equipment is proposed from Texas Instruments, Inc. 1993 For example, J.P.Sampsell, "An Overview of the Didital Micromirror Device (DMD) and Its Application to Projection Display", and Society for Imformation Display International Symposium (SID'93) Digest of TechnicalPapers, pp 1012-1015 and May 1993 Refer to. This projection equipment has the structure where the mirror (micro mirror) was aligned on [each] many SRAM. And incidence of the light from the light source of RGB is carried out to these mirrors. And each mirror is moved based on the signal from SRAM (making it rotate), and the direction of the light injected from a mirror is changed. The light reflected in the suitable direction in the mirror by arranging the screen can be made to project on a screen. That is, an image can be projected on a screen by inputting an image control signal into SRAM. This condition is typically shown in (A) of drawing 12 .
[0005]
[Problem(s) to be Solved by the Invention] The flat-surface configuration of each mirror in a digital micro mirror device is a rectangle. And the mirror is being fixed on the silicon substrate among the four corners of a mirror in two corners on one diagonal line (it is called a fixed portion for convenience). Two corners on the diagonal line of everything but a mirror are put on the free condition. The typical sectional view of one mirror which met one diagonal line is shown in (B) of drawing 12 . Each mirror is formed on the aluminum film and supported with two stanchions in the condition of having floated in the air. Since the mirror in this digital micro mirror device is driven (that is, the direction of the light injected from a mirror is changed), a certain potential is given to the

aluminum film and Coulomb force is used between the aluminum film and an electrode by on the other hand making into potential opposite to the aluminum film the counterelectrode which countered the mirror. By this, a mirror can be rotated by using a fixed portion as the supporting point. Coulomb force is changed by changing the potential of the counterelectrode electrically connected to SRAM formed in the semi-conductor substrate with 1 and 0 (quantity, low), and the roll control of a mirror is performed.

[0006] When a mirror drives, stress joins the aluminum film. That is, loads, such as torsion, join the fixed portion of the mirror which consists of the aluminum film. Consequently, the metal fatigue occurs into this part and the aluminum film which constitutes the fixed portion of a mirror is damaged. Therefore, the dependability of the fixed portion of a mirror is governing the dependability of a digital micro mirror device. So, it is one of the keys of utilization of the projection equipment using a digital micro mirror device to raise the dependability of this fixed portion. Moreover, since the minute metal membrane has structure which floated in the air, the problem of being weak is also in physical irritation, such as contact.

[0007] Therefore, the purpose of this invention has high dependability and a long life, and is to offer the digital micro mirror device with which the drive circuit was simplified.

[0008]

[Means for Solving the Problem] The digital micro mirror device of this invention for attaining the above-mentioned purpose the micro mirror section of one (b), and (b) — this — with one position control means for controlling the location of the micro mirror section established corresponding to the one micro mirror section (Ha) one transistor component for controlling this position control means — since — two or more constituted micro mirror components are arranged, and it changes, and is characterized by attaching this micro mirror section free [migration] to a position control means.

[0009] As position control of the micro mirror section, control of the distance between a position control means and the micro mirror section and control of the include angle of the micro mirror section to a position control means can be mentioned. The micro mirror section is not being strongly fixed to a position control means.

[0010] In the digital micro mirror device of this invention, the micro mirror section is equipped with the permanent magnet, a position control means can consist of an electromagnet, and it can consider as the configuration which controls the location of the micro mirror section by electromagnetic force which connects with the transistor component electrically and a position control means generates by control of a transistor component.

[0011] In this case, the 1st mode by which the united stanchion is prepared in the lower part of the micro mirror section, this stanchion consists of a permanent magnet, and this stanchion is arranged near the position control means, Or the united stanchion is prepared in the lower part of the micro mirror section. The 2nd mode of this stanchion by which the permanent magnet layer is prepared at least in the pars basilaris ossis occipitalis, and this stanchion is arranged near the position control means, Furthermore, the united stanchion is prepared in the lower part of the micro mirror section again, the base of this micro mirror section and the external surface of a stanchion are equipped with the permanent magnet layer, and this stanchion can mention the 3rd mode arranged near the position control means. It is desirable to prepare the guide section in a micro mirror component so that the micro mirror section's dedropping [a micro mirror component to] may not be found.

[0012] Or the digital micro mirror device of this invention for attaining the above-mentioned purpose again The transistor component formed in the (b) semi-conductor substrate, and the position control means which was established on the insulating layer formed on the (b) this transistor component, and was electrically connected to the transistor component, Consist of a micro mirror body and a stanchion and a micro mirror body is arranged on the guide layer formed on the position control means. (Ha) the micro mirror section by which the stanchion is contained free [migration] by the hole prepared in the guide layer, and the location of a stanchion is controlled by actuation of a position control means — since — it is characterized by arranging two or more constituted micro mirror components, and changing.

[0013] Although the light reflex side of the micro mirror section can be constituted from any ingredients, and may moreover be a monolayer or the number of them may be [two or more] as long

as it is the ingredient which reflects a suitable quantity of light, it is desirable to use aluminum, an aluminium alloy, nickel, chromium, copper, silver, etc. especially. The permanent magnet (or permanent magnet layer) with which the micro mirror section was equipped can consist of ferromagnetic ingredients, such as iron, cobalt, and nickel. When it constitutes a position control means from an electromagnet, an electromagnet can consist of a core part (core section) which consists of ferromagnetic ingredients, such as iron, cobalt, and nickel, and a coil which encloses this core part. As a transistor component, although the transistor component of any formats can be used, a MOS transistor component and a bipolar transistor component can be mentioned, for example.
[0014]
[Function] In the digital micro mirror device of this invention, the micro mirror section is attached free [migration] to the position control means, and the micro mirror section is not being strongly fixed like a Prior art. Therefore, force, such as torsion, cannot join the micro mirror section, but high dependability can be given to a digital micro mirror device. Moreover, if the drive of the micro mirror section is not driven by Coulomb force like the conventional technique but is driven magnetically, driving force is improved and stabilized and positive actuation of a micro mirror device can be guaranteed.
[0015]
[Example] Hereafter, with reference to a drawing, this invention is explained based on an example. In addition, the united stanchion is prepared in the lower part of the micro mirror section, and this stanchion consists of a permanent magnet and, as for an example 1, is related with the 1st mode by which the stanchion is arranged near the position control means. Moreover, it is prepared, and the permanent magnet layer is prepared in the pars basilaris ossis occipitalis at least, and the stanchion with which the example 2 was united in the lower part of the micro mirror section is related with the 2nd mode of this stanchion by which the stanchion is arranged near the position control means. Furthermore, the united stanchion is prepared in the lower part of the micro mirror section, the base of a micro mirror and the external surface of a stanchion are equipped with the permanent magnet layer, and an example 3 is related with the 3rd mode by which this stanchion is arranged near the position control means.
[0016] (Example 1) The digital micro mirror device of this invention arranges two or more micro mirror components, and changes. a part with each of a micro mirror component typical to drawing 1 -- a sectional view is shown — as — (**) — the one micro mirror sections 43 and 42 and (**) — one transistor components 15 and 16 for controlling one position control means 30, 35, and 32 and this (Ha) position control means for controlling the location of the micro mirror section prepared corresponding to these one micro mirror sections 43 and 42 — since — it changes. And the micro mirror sections 43 and 42 are attached free [migration] to the position control means 30, 35, and 32.

[0017] The micro mirror sections 43 and 42 are equipped with the permanent magnet 42. On the other hand, the position control means 30, 35, and 32 consist of a kind of electromagnet, and the end is connected to the transistor components 15 and 16. The transistor components 15 and 16 are MOS transistor components. And the location of the micro mirror sections 43 and 42 is controlled by electromagnetic force generated for the position control means 30, 35, and 32 by control of the transistor components 15 and 16. The location of the micro mirror sections 43 and 42 is controlled using the attraction and repulsive force specifically produced between the permanent magnets 42 with which the position control means 30 and 35 were equipped with by the on-off control of the transistor components 15 and 16, and the micro mirror sections 43 and 42 were equipped in the current by a sink and the electromagnetic force which this generates with the position control means 30, 35, and 32.
[0018] In an example 1, the micro mirror sections 43 and 42 consist of stanchions 42 been [stanchions / it] united and prepared in the lower part of the micro mirror body 43 and the micro mirror body 43, and this stanchion 42 consists of a permanent magnet. And the stanchion 42 is arranged free [migration] near the position control means 30, 35, and 32. Moreover, the guide section 44 for restricting a motion of the micro mirror section is formed near the micro mirror body 43.
[0019] Position control of the micro mirror section is performed by vertical movement of the micro

mirror section to a position control means in an example 1. In drawing 1 , the micro mirror section illustrated the condition of being in the location most distant from the position control means.
[0020] Again or the digital micro mirror device of this invention The transistor components 15 and 16 typical to drawing 1 formed in the (b) semi-conductor substrate 10 as a part was shown in a sectional view, The position control means 30, 35, and 32 which were established on the (b) transistor component 15 and the insulating layer 20 formed on 16, and were electrically connected to the transistor component, Consist of the micro mirror body 43 and a stanchion 42, and the micro mirror body 43 is arranged on the guide layer 40 formed on the position control means. (Ha) the micro mirror sections 43 and 42 by which the stanchion 42 is contained free [migration] by hole 40A prepared in the guide layer 40, and the location of a stanchion 42 is controlled by actuation of a position control means — since -- two or more constituted micro mirror components are arranged, and it changes.
[0021] The principle of operation of the micro mirror component of this invention is shown in drawing 2 . If the transistor components 15 and 16 are in the condition of OFF as shown in (A) of drawing 2 , the current is not flowing for the position control means connected to the transistor component. Therefore, electromagnetic force does not occur for the position control means 30, 32, and 35, but it is put on distance with fixed micro mirror section and position control means with the attraction committed between the permanent magnet 42 with which the micro mirror section was equipped, and this position control means. Consequently, the light which carried out incidence to the micro mirror section is injected in the predetermined direction. The light injected from the micro mirror section is interrupted by the shield which has opening prepared between the digital micro mirror device and the screen, and does not reach a screen.
[0022] If a transistor component is made into an ON state as shown in (B) of drawing 2 , a current will flow for the position control means connected to the transistor components 15 and 16, and electromagnetic force will occur for the position control means 30, 32, and 35. According to the repulsive force committed between the permanent magnet 42 with which the micro mirror section was equipped, and this position control means, the micro mirror section moves in the direction which separates from a position control means. Consequently, the injection direction of the light which carried out incidence to the micro mirror section changes from injection before actuation of a position control means. The light injected from the micro mirror section passes opening of the shield formed between the digital micro mirror device and the screen, and reaches a screen. In addition, it is good even if contrary to the above-mentioned explanation in the attainment condition to the screen of the light in the on-off condition of a transistor component.
[0023] In projecting an image on a screen, it carries out incidence of the color filter of RGB of the disk mold which rotates the light injected from the light source with the rotational speed of for example, 3600rpm to through and the digital micro mirror device of this invention. A white light is changed into three colors of RGB by rotating the color filter of a disk mold. The light of this RGB is reflected in the micro mirror section of a digital micro mirror device. And only the light in which the transistor component was reflected in the micro mirror section of the micro mirror component in an ON state (it is an OFF state depending on a configuration) reaches a screen through a projection lens. By carrying out time sharing of the display time of RGB, it is possible to control gradation.
[0024] Hereafter, the production approach of the digital micro mirror device of the example 1 shown in drawing 1 is explained with reference to typical drawing 3 which is sectional views a part, such as a semi-conductor substrate, - drawing 6 .
[0025] [Process -100] Based on the conventional approach, a MOS transistor component is first produced to the silicon semi-conductor substrate 10 (refer to (A) of drawing 3). Therefore, after first forming the component isolation region 11 which changes from SiO2 to the silicon semi-conductor substrate 10 by the conventional approach, the front face of the silicon semi-conductor substrate 10 is oxidized, and gate oxide 12 is formed. Subsequently, after making a polish recon layer deposit on the whole surface with a CVD method for example, with a photolithography technique and a dry etching technique, a polish recon layer is removed alternatively and the gate electrode 13 is formed. Then, the impurity ion implantation for forming LDD structure by the conventional approach is performed, and, subsequently to the side attachment wall of a gate electrode, the gate sidewall 14 which consists of SiO2 is formed. In this way, the gate polar zone 15 which consisted of the gate electrodes 13 and the gate sidewalls 14 which consist of gate oxide 12 and polish recon can be

formed. Then, an impurity ion implantation is performed and the source drain field 16 is formed in the silicon semi-conductor substrate 10. Each of these processes can be performed based on a well-known approach.
[0026] The position control means electrically connected to the MOS transistor component is formed above a MOS transistor component through an insulating layer after that [[process -110]].
[0027] [Process-110A] Therefore, first, it changes from SiO2 to the whole surface, and the insulating layer 20 with a thickness of 0.5 micrometers is formed in it with a CVD method. The conditions of a CVD method are illustrated below.
Gas used: TEOS=50sccm substrate temperature: 720-degreeC pressure : 40Pa [0028] In addition, the ingredient which constitutes an insulating layer 20 is not limited to SiO2, but can mention what carried out the laminating of other well-known insulating material, for example, BPSG, PSG and BSG, AsSG, PbSG, SbSG, SOG, SiON, SiN(s), or these insulator layers.
[0029] A photolithography technique and a dry etching technique are used for the upper insulating layer 20 of [process-110B], next the source drain field 16, and opening 21 is formed. The conditions of dry etching can be carried out as follows.
Gas used : C4F8=50sccmRF power: 1200W pressure : 2Pa [0030] The inside of opening 21 is embedded with a metal wiring material after that [[process-110C]]. Therefore, Ti and the TiN layer 22 are made to deposit from the bottom on the insulating layer 20 including the inside of opening 21 first using a spatter. This TiN/Ti layer achieves the function as the so-called barrier metal layer and a contact resistance reduction layer. Subsequently, for example, the tungsten (W) layer 23 is made to deposit on the TiN/Ti layer 22 including the inside of opening 21 using the so-called blanket tungsten CVD method. Then, the tungsten layer and TiN/Ti layer on an insulating layer 20 are removed, and only the inside of opening 21 is embedded in the TiN/Ti layer 22 and the tungsten layer 23 (refer to (B) of drawing 3). The etchback conditions of a tungsten layer and a TiN/Ti layer are illustrated below in the membrane formation conditions of Ti layer and a TiN layer, the membrane formation conditions of the tungsten layer by the blanket tungsten CVD method, and a list.
Membrane formation condition use gas of Ti layer : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : Membrane formation condition use gas of 30nmTiN layers : Ar/N2=40 / 70sccm power : 5kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : Membrane formation condition use gas of W layers by 70nm blanket tungsten CVD method : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : Condition use gas of 0.4-micrometer etchback : SF6=50sccm microwave power : 850WRF power : 150W pressure : 1.33Pa [0031] A position control means is formed on an insulating layer 20 after that [[process-110D]]. Therefore, the 1st conductive layer 30 which consists of aluminum or an aluminum system alloy (it may name generically and may be hereafter called aluminum system alloy) is first formed in the whole surface by the spatter. The formation conditions of the 1st conductive layer 30 are illustrated below.
Gas used : Ar=40sccm power : 22.5kW membrane formation temperature : 150-degreeC pressure : 0.47Pa thickness : Various aluminium alloys, such as pure aluminium, aluminum-Si, aluminum-Cu, aluminum-Si-Cu, aluminum-germanium, and aluminum-Si-germanium, can be illustrated as 0.3 micrometers and an aluminum system alloy.
[0032] Patterning of the 1st conductive layer 30 is carried out to a desired flat-surface configuration after that [[process-110E]] using a photolithography technique and a dry etching technique. Dry etching conditions can be carried out as follows.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa [0033] In addition, after skipping the process which embeds opening 21 in the tungsten layer 23 with a blanket tungsten CVD method and making aluminum system alloy layer deposit in a spatter on a TiN layer / Ti layer 22, the 1st conductive layer 30 by which embedded the inside of opening 21 with aluminum system alloy, and patterning was carried out collectively can also be obtained by removing alternatively aluminum system alloy layer and the TiN/Ti layer 22 on an insulating layer 20.
[0034] Instead of aluminum system alloy which constitutes the 1st conductive layer 30, metal wiring materials, such as W, Cu, and Ag, can be used. Moreover, the formation approach of these metal wiring materials is not limited to a spatter, for example, can also use a CVD method.
[0035] [Process-110F], next bias ECR The 1st flat layer insulation layer 31 which consists of SiN is

formed in the whole surface with a CVD method on the whole surface (refer to (C) of drawing 3). The formation conditions of the 1st layer insulation layer 31 are illustrated below.
Gas used : SiH4/N2O=21/35sccm microwave power : 1000WRF power : 300W membrane formation temperature : 450-degreeC pressure : 0.01Pa [0036] The heart (core) layer 32 which consists of iron is formed by the spatter on the 1st layer insulation layer 31 after that [[process-110G]]. The membrane formation conditions of a core layer 32 are illustrated below.
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 70nm [0037] In addition, Co, nickel, etc. can also constitute a core layer 32 from ferromagnetic ingredients, such as an alloy of these ingredients, and an oxide, instead of iron.
[0038] Patterning of the core layer 32 is carried out to a desired flat-surface configuration (for example, rectangle) using [process-110H] next a photolithography technique, and a dry etching technique (refer to (A) of drawing 4). Dry etching conditions can be carried out as follows.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa substrate temperature : 350-degreeC [0039] After that [[process-110I]], bias ECR The 2nd flat layer insulation layer 33 which consists of SiN is formed in the whole surface with a CVD method on the whole surface. The formation conditions of the 2nd layer insulation layer 33 can be made to be the same as that of the formation conditions of the 1st layer insulation layer 31. Subsequently, opening 34 is formed in the 2nd layer insulation layer 33 using a photolithography technique and a dry etching technique. Dry etching conditions are illustrated below.
Gas used : C4F8=50sccmRF power : 1200W pressure : 2Pa [0040] In addition, the ingredient which constitutes the 1st layer insulation layer 31 or the 2nd layer insulation layer 33 is not limited to SiN, but can mention what carried out the laminating of other well-known insulating materials 2, for example, SiO, BPSG, PSG and BSG, AsSG, PbSG, SbSG, SOG, SiON(s), or these insulator layers.
[0041] In this way, the structure shown in (B) of drawing 4 can be acquired. In addition, in (B) of drawing 4 , although it is illustrated as if opening was formed also in the core layer 32, opening is not formed in the core layer 32 in fact. Opening 34 is formed only in the 2nd layer insulation layer 33. Moreover, in (B) of drawing 4 , although the condition that opening 34 was formed in the part on the right-hand side of [each] the field of the 1st conductive layer 30 by which patterning was carried out was shown, opening (not shown) is formed also in the part on the left-hand side of [each] the 1st conductive layer 30 by which patterning was carried out in fact.
[0042] For example, a TiN layer (not shown) is formed on the [process-110J], next 2nd layer insulation layer 33 which include the inside of opening 34 in a spatter, and the 2nd conductive layer 35 which consists of a tungsten is further formed with a blanket tungsten CVD method on it. The membrane formation conditions of a TiN layer can be made to be the same as that of the membrane formation conditions of the TiN layer of [process-11C]. Membrane formation condition use gas of the 2nd conductive layer : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : 0.3 micrometers [0043] Patterning of the 2nd conductive layer 35 and a TiN layer is performed on the etchback conditions of [process-110C], and the same conditions after that [[process-110K]] using a photolithography technique and a dry etching technique.
[0044] In addition, the 2nd conductive layer 35 can also be formed instead of formation of the 2nd conductive layer 35 by the blanket tungsten CVD method by forming other metal wiring materials with a spatter or a CVD method on the 2nd layer insulation layer 33 including the inside of opening 34.
[0045] [Process-110L] Further, after making the 3rd layer insulation layer 36 which consists of BPSG deposit on the whole surface, flattening processing of the 3rd layer insulation layer 36 by heating is performed. In this way, the structure shown in (A) of drawing 5 can be acquired. The membrane formation conditions of the 3rd layer insulation layer 36 are illustrated below.
Gas used : SiH4/PH3/B-2H6/O2/N2=80/7/7/1000/32000sccm membrane formation temperature : 400-degreeC pressure : 1.0x105Pa thickness : 0.15 micrometers [0046] In addition, the ingredient which constitutes the 3rd layer insulation layer 36 is not limited to BPSG, but if it is an ingredient which is not etched into coincidence in case it etches the sacrifice layer formed behind, it can use any well-known insulating materials.
[0047] In this way, the position control means which is a kind of electromagnet which consisted of the 1st conductive layer 30 which is equivalent to a coil at the core layer 32 which consists of iron, for example and is equivalent to the core part (core section) of an electromagnet, and a list, and the

2nd conductive layer 35 (these layers 30 and 35 are electrically connected one by one through opening 34 and opening which is not illustrated) is completed. The end (a part of 1st conductive layer 30 by which patterning was carried out) of a coil is electrically connected with the source drain field 16 of a MOS transistor component through the TiN/Ti layer 22 and the tungsten layer 23 which were embedded in opening 21. the edge (in or the case other edges of the 1st conductive layer 30) of the 2nd conductive layer 35 which is the other end of a coil on the other hand — for example, it is grounded (not shown). By this, if a MOS transistor component is turned on, a current will flow in the coil which consisted of the 1st conductive layer 30 and 2nd conductive layer 35, and a field will occur.

[0048] [A process -120], next the micro mirror sections 43 and 42 are formed above the position control means 30, 35, and 32.

[0049] [Process-120A] Therefore, the guide layer 40 which consists of polish recon is first formed in the whole surface. The CVD formation conditions of the guide layer 40 are illustrated below.

Gas used : SiH4/helium=500 / 50sccm pressure : 80Pa membrane formation temperature : 400-degreeC thickness : 0.8 micrometers [0050] In addition, if it is the ingredient which is not etched into coincidence and is the ingredient which does not reflect light in case the sacrifice layer formed behind is etched instead of polish recon as an ingredient which constitutes a guide layer, any well-known ingredients can be used.

[0051] Hole 40A is formed in the guide layer 40 which consists of polish recon with a photolithography technique and a dry etching technique after that [[process-120B]]. In addition, the stanchion behind formed in this hole 40A is contained. The conditions of dry etching can be made to be the same as that of [process-110I].

[0052] [Process-120C] Subsequently the sacrifice layer (detached core) 41 which consists of SiO2 is formed with the CVD method of the conditions illustrated below all over the guide layer 40 containing hole 40A (refer to (B) of drawing 5).

Gas used : SiH4/O2/N2=80/1000/32000sccm membrane formation temperature : 400-degreeC pressure : 1.0x105Pa thickness : 50nm [0053] An iron layer is made to deposit on the whole surface in the spatter of the conditions of [process-120D] after that, for example, the following.

Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 1.0 micrometers [0054] The magnet prepared independently is brought close to an iron layer, and an iron layer is made to magnetize in [process-120E] and this condition. Then, using a photolithography technique and a dry etching technique, patterning of the iron layer is carried out and it leaves an iron layer into hole 40A. Dry etching conditions can be made to be the same as that of [process-110H]. In this way, the structure shown in (A) of drawing 6 can be acquired. The iron layer left behind into hole 40A is equivalent to a stanchion 42. Moreover, the stanchion 42 which consists of an iron layer is permanent-magnet-ized.

[0055] For example, aluminum system alloy layer is formed by the spatter on [process-120F] next the sacrifice layer 41, and a stanchion 42. The formation conditions of aluminum system alloy layer are illustrated below.

Gas used : Ar=40sccm power : 22.5kW membrane formation temperature : 500-degreeC pressure : 0.47Pa thickness : 0.3 micrometers [0056] After that [[process-120G]], using a photolithography technique and a dry etching technique, patterning of the aluminum system alloy layer is carried out, and the micro mirror body 43 which consists of aluminum system alloy layer is formed. The conditions of dry etching can be made to be the same as that of [process-110E]. In this way, the structure shown in (B) of drawing 6 can be acquired.

[0057] After forming opening in [process-120H], next the about 43 micro mirror body sacrifice layer 41, for example, a polish recon layer is made to deposit on the whole surface. And a polish recon layer is removed alternatively and perpendicular wall 44A which constitutes the guide section is formed from a polish recon layer. Next, the sacrifice layer 45 which consists, for example of SiO2 is made to deposit on the whole surface (refer to (A) of drawing 7). Then, a polish recon layer is made to deposit on the whole surface again, this polish recon layer is removed alternatively, and horizontal height 44B which constitutes the guide section is formed (refer to (B) of drawing 7).

[0058] The sacrifice layers 45 and 41 which change from SiO2 to the [process-120I] last by the dry etching method are removed. The conditions of dry etching are illustrated below.

Gas used : CF4=100sccmRF power: 50W pressure : 6Pa [0059] In this way, the micro mirror component of the structure shown in drawing 1 is producible.
[0060] (Example 2) An example 2 is deformation of an example 1 and the structure of the micro mirror section is different from an example 1. namely, the 2nd voice by which the united stanchion is prepared in the lower part of the micro mirror section, as for the example 2, the permanent magnet layer 50 is formed in the pars basilaris ossis occipitalis (it sets in the example 2 and is the whole surface of the external surface of a stanchion) of the stanchion which consists of this polish recon, and the stanchion is arranged free [migration] near the position control means — it is related like. Moreover, the micro mirror body in the micro mirror section is the two-layer structure of aluminum system alloy layer 52 and the tungsten layer 53, and light is reflected by the tungsten layer 53.
[0061] In production of the digital micro mirror device of an example 2, formation of a position control means, i.e., the formation process of the 3rd layer insulation layer 36, can presuppose that it is the same as that of an example 1. So, only the formation approach of the micro mirror section is hereafter explained with reference to drawing 8 and drawing 9 .
[0062] [Process-200A] After forming the guide layer 40 which consists of polish recon like [process-120A] - [process-120C] on the 3rd layer insulation layer 36, hole 40A is formed in the guide layer 40. [of an example 1] Subsequently, the sacrifice layer (detached core) 41 which consists of SiO2 all over the guide layer 40 containing hole 40A is formed with a CVD method (refer to (A) of drawing 8).
[0063] An iron layer is made to deposit on the whole surface in the spatter of the conditions of [process-200B] after that, for example, the following. Hole 40A makes thickness of an iron layer the thickness which is not embedded by the iron layer.
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 70nm [0064] The magnet independently prepared in the state of [this] [process-200C] is brought close to an iron layer, an iron layer is magnetized, and an iron layer is permanent-magnet-ized.
[0065] After that [[process-200D]], using a photolithography technique and a dry etching technique, patterning of the iron layer is carried out and it leaves an iron layer into hole 40A. Dry etching conditions can be made to be the same as that of [process-110H] of an example 1. In this way, the permanent magnet layer 50 can be formed in the pars basilaris ossis occipitalis and the side-attachment-wall section of hole 40A.
[0066] [Process-200E] Subsequently to the whole surface, the polish recon layer 51 is formed. The CVD formation conditions of the polish recon layer 51 can be made to be the same as that of [process-120A] of an example 1.
[0067] After that [[process-200F]], whole surface etchback of the polish recon layer 51 is carried out, and it leaves the polish recon layer 51 only in the crevice of the permanent magnet layer 50 formed in the inside of hole 40A. In this way, the structure shown in (B) of drawing 8 can be acquired. The permanent magnet layer 50 and the polish recon layer 51 which were left behind into hole 40A are equivalent to a stanchion. In other words, even if there are few stanchions, the permanent magnet layer 50 is formed in a pars basilaris ossis occipitalis (it sets in the example 2 and they are all the external surface of a stanchion). The etchback conditions of a polish recon layer are illustrated below.
Gas used : C2Cl3F3/SF6=65/5sccm microwave power : 850WRF power : 150W pressure : 1.33Pa [0068] aluminum system alloy layer 52 is formed on the whole surface on the same conditions as [process-120F] of an example 1 after that [[process-200G]]. Next, the tungsten layer 53 is formed on aluminum system alloy layer 52 with the CVD method illustrated below.
Gas used : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : 30nm [0069] The tungsten layer 53 and aluminum system alloy layer 52 are etched into a desired pattern using [process-200H] next a photolithography technique, and a dry etching technique (refer to (C) of drawing 8). Etching conditions are illustrated below.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa [0070] The tungsten layer 54 with a thickness of 100nm is made to deposit on the whole surface with the CVD method of the same conditions as [process-200G] again after that [[process-200I]]. And etchback of the tungsten layer 54 is carried out on the same conditions as [process-110C] of an example 1. In this way, the structure shown in (A) of drawing 9 can be acquired. The top face and the

side face are covered with the tungsten layers 53 and 54, and aluminum system alloy layer 52 can give high dependability to a micro mirror body.
[0071] the dilution fluoric acid solution (HF:H2O=5:100) after forming the guide section (not shown) near the micro mirror body 43 by the same approach as [process-120H] of an example 1 after that [[process-200J]] — for example, sacrifice layer 41 grade is removed by being immersed for 5 minutes. In this way, the micro mirror section of the structure shown in (B) of drawing 9 is producible. In addition, finally the tungsten layers 53 and 54 of aluminum system alloy layer 52 top and a side attachment wall may be removed by the plasma-etching method illustrated below.
Gas used : CF4=100sccmRF power: 50W pressure : 6Pa [0072] (Example 3) An example 3 is also deformation of an example 1 and the structure of the micro mirror section is different from an example 1. namely, the 3rd voice by which the united stanchion is prepared in the lower part of the micro mirror section, as for the example 3, the base (specifically base of a micro mirror body) of the micro mirror section and the external surface of a stanchion are equipped with the permanent magnet layer, and this stanchion is arranged free [migration] near the position control means — it is related like. Moreover, the micro mirror body in the micro mirror section is the two-layer structure of the polish recon layer 62 and aluminum system alloy layer 63, and light is reflected by aluminum system alloy layer 63. Although the sacrifice layer was formed from SiO2 in the example 1, in the example 3, the sacrifice layer was formed from the organic resist ingredient. Moreover, a permanent magnet layer consists of cobalt (Co).
[0073] In production of the digital micro mirror device of an example 3, formation of a position control means, i.e., the formation process of the 3rd layer insulation layer 36, can presuppose that it is the same as that of an example 1. So, only the formation approach of the micro mirror section is hereafter explained with reference to drawing 10 and drawing 11 .
[0074] [Process-300A] After forming the guide layer 40 which consists of polish recon like [process-120A] - [process-120B] on the 3rd layer insulation layer 36, hole 40A is formed in a guide layer. [of an example 1] Subsequently, the sacrifice layer (detached core) 60 which consists of an organic resist ingredient all over the guide layer 40 containing hole 40A is formed on a spin coat (refer to (A) of drawing 10). The formation conditions of the sacrifice layer 60 are illustrated below.
Use resist ingredient : OFPR 30cp spreading coating-machine engine speed : Baking after 2000rpm spreading : 100-degreeC [0075] The Co layer 61 is made to deposit all over the upper [of the sacrifice layer 60 which includes the inside of hole 40A in the spatter of the conditions of [process-300B] after that, for example, the following,].
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 0.3 micrometers [0076] The magnet independently prepared in the state of [this] [process-300C] is brought close to the Co layer 61, the Co layer 61 is magnetized, and the Co layer 61 is permanent-magnet-ized. That is, the Co layer 61 turns into a permanent magnet layer.

[0077] The polish recon layer 62 with a thickness of 0.5 micrometers is formed all over after that [[process-300D]]. The CVD formation conditions of the polish recon layer 62 can be made to be the same as that of [process-120A] of an example 1, and abbreviation. In addition, the polish recon layer 62 is deposited also in the crevice of the Co layer 61 deposited in hole 40A, and this polish recon layer is equivalent to a stanchion.
[0078] aluminum system alloy layer 63 is formed on the whole surface on the same conditions as [process-120F] of an example 1 after that [[process-300E]]. In this way, the structure shown in (B) of drawing 10 can be acquired. It has the permanent magnet layer which changes from the Co layer 61 to the base of the micro mirror sections 62 and 63, and the external surface of a stanchion.
[0079] Patterning is carried out using [process-300F] next a photolithography technique, and a dry etching technique on the conditions which illustrate aluminum system alloy layer 63, the polish recon layer 62, and the Co layer 61 below.
patterning use gas [of aluminum system alloy layer]: — patterning use gas [ ] of a 50W pressure : 0.016Pa polish recon layer — : C4F8/Ar — =50/10sccmRF power : 1200W Pressure : [ ] — in addition, patterning of the 2Pa of the Co layers 61 can be carried out by the over etching after the dry etching of the polish recon layer 62. : BCl3/Cl2=60 / 90sccm microwave power: 1000WRF power
[0080] Oxygen plasma-asher processing of the conditions of [process-300G] after that, for example,

the following, is performed, and the sacrifice layer 60 which consists of an organic resist ingredient is removed.
Gas used : O2=20sccmRF plasma : 200V pressure : The sacrifice layer 60 is completely removed by the fuming nitric acid after 1atm oxygen plasma-asher processing.
[0081] As mentioned above, although the digital micro mirror device of this invention was explained based on the desirable example, this invention is not limited to these examples. The various membrane formation conditions of having explained in each example are instantiation, and can be changed suitably. The membrane formation approach can also replace a spatter and a CVD method suitably.
[0082] In an example, although the position control of the micro mirror section was chiefly based on the vertical movement to a position control means, it may perform position control (include-angle control) of the micro mirror section to a position control means by what the micro mirror section is rotated for (an include-angle variation rate is carried out). In this case, what is necessary is just to, make different the clearance between horizontal height 44B and the guide layers 40 which constitute the guide section 44 for example the left-hand side and on the right-hand side of drawing 1 , and the guide section 44 may be formed near the one side of the micro mirror section. [of the micro mirror section] . Or what is necessary is to prepare one height or the pin section in the side attachment wall of a stanchion, and just to form the hole which engages with the height or the pin section concerning the side attachment wall of hole 40A gently again. The structure of a position control means is instantiation and can change structure suitably.
[0083]
[Effect of the Invention] In the conventional digital micro mirror device, since the mirror was rotated when the fixed portion of a mirror was twisted, it was easy to damage a fixed portion and endurance was bad. being appropriate — it is alike, and in the digital micro mirror device of this invention, a stanchion and a micro mirror body are united, moreover, it is not fixed to a position control means, but the micro mirror section is arranged free [migration]. therefore, even if it drives the micro mirror section, the force in which it does not want does not join the micro mirror section, but from the conventional micro mirror device, endurance is markedly alike and improves. Moreover, since the micro mirror section can be driven with one transistor component, the degree of integration of the micro mirror section improves.
[0084] And since the light reflex side of the micro mirror section is constituted from a metallic material, the brightness of the image on which about 100% is obtained and the reflection factor of light is projected from a digital micro mirror device is very high, and lightweight-ization is attained also for projection equipment. On the other hand, since the display using the conventional liquid crystal device has the permeability of light very as bad as several %, its brightness is low. It becomes possible to realize high definition of the monitor for HD, lightweight-izing, and low-pricing especially.
[0085] furthermore, since the driving force of the digital micro mirror device of this invention is boiled markedly and improves, projection of the stable image is securable from the digital micro mirror device using the conventional Coulomb force.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the digital micro mirror device used with image projection equipment.

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PRIOR ART

[Description of the Prior Art] In recent years, big screen-ization of television advances with quality improvement of television broadcasting etc., and the television set carrying the big screen Braun tube 29 inches or more is becoming in use. However, while a television set big-screen-izes, the weight increases, for example, AUW is set to 60kg or more in the television set which is 29 inches, and migration is difficult. Although the general broadcast of HDVS is also becoming close, enlargement progresses further and the receiving set using the Braun tube for HDVS has the amount of Oshige of 90kg or more. If it already becomes such weight, it will become very difficult to move the receiving set installed once later.

[0003] On the other hand, the display of a projection method using a liquid crystal device is devised in recent years. In this indicating equipment, in light, it is making a liquid crystal device penetrate, and the image formed on the liquid crystal device is projected on an image screen. In such an indicating equipment, the heavy Braun tube becomes unnecessary, an indicating equipment only consists of the light sources and the liquid crystal devices for lighting, and an indicating equipment becomes very light. It is necessary to make light penetrate the inside of a liquid crystal device in this kind of indicating equipment, it is alike and has the problem that the light transmittance of a liquid crystal device is as low as several %, and the appropriate image projected on the screen is dark.

[0004] In recent years, projection equipment using the digital micro mirror device (Digital Mirror Device) as new projection equipment is proposed from Texas Instruments, Inc. 1993 For example, J.P.Sampsell, "An Overview of the Didital Micromirror Device (DMD) and Its Application to Projection Display", and Society for Imformation Display International Symposium (SID'93) Digest of TechnicalPapers, pp 1012-1015 and May 1993 Refer to. This projection equipment has the structure where the mirror (micro mirror) was aligned on [each] many SRAM. And incidence of the light from the light source of RGB is carried out to these mirrors. And each mirror is moved based on the signal from SRAM (making it rotate), and the direction of the light injected from a mirror is changed. The light reflected in the suitable direction in the mirror by arranging the screen can be made to project on a screen. That is, an image can be projected on a screen by inputting an image control signal into SRAM. This condition is typically shown in (A) of drawing 12 .

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EFFECT OF THE INVENTION

[Effect of the Invention] In the conventional digital micro mirror device, since the mirror was rotated when the fixed portion of a mirror was twisted, it was easy to damage a fixed portion and endurance was bad. being appropriate — it is alike; and in the digital micro mirror device of this invention, a stanchion and a micro mirror body are united, moreover, it is not fixed to a position control means, but the micro mirror section is arranged free [migration]. therefore, even if it drives the micro mirror section, the force in which it does not want does not join the micro mirror section, but from the conventional micro mirror device, endurance is markedly alike and improves. Moreover, since the micro mirror section can be driven with one transistor component, the degree of integration of the micro mirror section improves.
[0084] And since the light reflex side of the micro mirror section is constituted from a metallic material, the brightness of the image on which about 100% is obtained and the reflection factor of light is projected from a digital micro mirror device is very high, and lightweight-ization is attained also for projection equipment. On the other hand, since the display using the conventional liquid crystal device has the permeability of light very as bad as several %, its brightness is low. It becomes possible to realize high definition of the monitor for HD, lightweight-izing, and low-pricing especially.
[0085] furthermore, since the driving force of the digital micro mirror device of this invention is boiled markedly and improves, projection of the stable image is securable from the digital micro mirror device using the conventional Coulomb force.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The flat-surface configuration of each mirror in a digital micro mirror device is a rectangle. And the mirror is being fixed on the silicon substrate among the four corners of a mirror in two corners on one diagonal line (it is called a fixed portion for convenience). Two corners on the diagonal line of everything but a mirror are put on the free condition. The typical sectional view of one mirror which met one diagonal line is shown in (B) of drawing 12 . Each mirror is formed on the aluminum film and supported with two stanchions in the condition of having floated in the air. Since the mirror in this digital micro mirror device is driven (that is, the direction of the light injected from a mirror is changed), a certain potential is given to the aluminum film and Coulomb force is used between the aluminum film and an electrode by on the other hand making into potential opposite to the aluminum film the counterelectrode which countered the mirror. By this, a mirror can be rotated by using a fixed portion as the supporting point. Coulomb force is changed by changing the potential of the counterelectrode electrically connected to SRAM formed in the semi-conductor substrate with 1 and 0 (quantity, low), and the roll control of a mirror is performed.

[0006] When a mirror drives, stress joins the aluminum film. That is, loads, such as torsion, join the fixed portion of the mirror which consists of the aluminum film. Consequently, the metal fatigue occurs into this part and the aluminum film which constitutes the fixed portion of a mirror is damaged. Therefore, the dependability of the fixed portion of a mirror is governing the dependability of a digital micro mirror device. So, it is one of the keys of utilization of the projection equipment using a digital micro mirror device to raise the dependability of this fixed portion. Moreover, since the minute metal membrane has structure which floated in the air, the problem of being weak is also in physical irritation, such as contact.

[0007] Therefore, the purpose of this invention has high dependability and a long life, and is to offer the digital micro mirror device with which the drive circuit was simplified.

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MEANS

[Means for Solving the Problem] The digital micro mirror device of this invention for attaining the above-mentioned purpose the micro mirror section of one (b), and (b) — this — with one position control means for controlling the location of the micro mirror section established corresponding to the one micro mirror section (Ha) one transistor component for controlling this position control means — since — two or more constituted micro mirror components are arranged, and it changes, and is characterized by attaching this micro mirror section free [migration] to a position control means.

[0009] As position control of the micro mirror section, control of the distance between a position control means and the micro mirror section and control of the include angle of the micro mirror section to a position control means can be mentioned. The micro mirror section is not being strongly fixed to a position control means.

[0010] In the digital micro mirror device of this invention, the micro mirror section is equipped with the permanent magnet, a position control means can consist of an electromagnet, and it can consider as the configuration which controls the location of the micro mirror section by electromagnetic force which connects with the transistor component electrically and a position control means generates by control of a transistor component.

[0011] In this case, the 1st mode by which the united stanchion is prepared in the lower part of the micro mirror section, this stanchion consists of a permanent magnet, and this stanchion is arranged near the position control means, Or the united stanchion is prepared in the lower part of the micro mirror section. The 2nd mode of this stanchion by which the permanent magnet layer is prepared at least in the pars basilaris ossis occipitalis, and this stanchion is arranged near the position control means, Furthermore, the united stanchion is prepared in the lower part of the micro mirror section again, the base of this micro mirror section and the external surface of a stanchion are equipped with the permanent magnet layer, and this stanchion can mention the 3rd mode arranged near the position control means. It is desirable to prepare the guide section in a micro mirror component so that the micro mirror section's dedropping [a micro mirror component to] may not be found.

[0012] Or the digital micro mirror device of this invention for attaining the above-mentioned purpose again The transistor component formed in the (b) semi-conductor substrate, and the position control means which was established on the insulating layer formed on the (b) this transistor component, and was electrically connected to the transistor component, Consist of a micro mirror body and a stanchion and a micro mirror body is arranged on the guide layer formed on the position control means. (Ha) the micro mirror section by which the stanchion is contained free [migration] by the hole prepared in the guide layer, and the location of a stanchion is controlled by actuation of a position control means — since — it is characterized by arranging two or more constituted micro mirror components, and changing.

[0013] Although the light reflex side of the micro mirror section can be constituted from any ingredients, and may moreover be a monolayer or the number of them may be [two or more] as long as it is the ingredient which reflects a suitable quantity of light, it is desirable to use aluminum, an aluminium alloy, nickel, chromium, copper, silver, etc. especially. The permanent magnet (or permanent magnet layer) with which the micro mirror section was equipped can consist of ferromagnetic ingredients, such as iron, cobalt, and nickel. When it constitutes a position control

means from an electromagnet, an electromagnet can consist of a core part (core section) which consists of ferromagnetic ingredients, such as iron, cobalt, and nickel, and a coil which encloses this core part. As a transistor component, although the transistor component of any formats can be used, a MOS transistor component and a bipolar transistor component can be mentioned, for example.

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OPERATION

[Function] In the digital micro mirror device of this invention, the micro mirror section is attached free [migration] to the position control means, and the micro mirror section is not being strongly fixed like a Prior art. Therefore, force, such as torsion, cannot join the micro mirror section, but high dependability can be given to a digital micro mirror device. Moreover, if the drive of the micro mirror section is not driven by Coulomb force like the conventional technique but is driven magnetically, driving force is improved and stabilized and positive actuation of a micro mirror device can be guaranteed.

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EXAMPLE

[Example] Hereafter, with reference to a drawing, this invention is explained based on an example. In addition, the united stanchion is prepared in the lower part of the micro mirror section, and this stanchion consists of a permanent magnet and, as for an example 1, is related with the 1st mode by which the stanchion is arranged near the position control means. Moreover, it is prepared, and the permanent magnet layer is prepared in the pars basilaris ossis occipitalis at least, and the stanchion with which the example 2 was united in the lower part of the micro mirror section is related with the 2nd mode of this stanchion by which the stanchion is arranged near the position control means. Furthermore, the united stanchion is prepared in the lower part of the micro mirror section, the base of a micro mirror and the external surface of a stanchion are equipped with the permanent magnet layer, and an example 3 is related with the 3rd mode by which this stanchion is arranged near the position control means.
[0016] (Example 1) The digital micro mirror device of this invention arranges two or more micro mirror components, and changes. a part with each of a micro mirror component typical to drawing 1 -- a sectional view is shown — as — (**) — the one micro mirror sections 43 and 42 and (**) — one transistor components 15 and 16 for controlling one position control means 30, 35, and 32 and this (Ha) position control means for controlling the location of the micro mirror section prepared corresponding to these one micro mirror sections 43 and 42 — since — it changes. And the micro mirror sections 43 and 42 are attached free [migration] to the position control means 30, 35, and 32.

[0017] The micro mirror sections 43 and 42 are equipped with the permanent magnet 42. On the other hand, the position control means 30, 35, and 32 consist of a kind of electromagnet, and the end is connected to the transistor components 15 and 16. The transistor components 15 and 16 are MOS transistor components. And the location of the micro mirror sections 43 and 42 is controlled by electromagnetic force generated for the position control means 30, 35, and 32 by control of the transistor components 15 and 16. The location of the micro mirror sections 43 and 42 is controlled using the attraction and repulsive force specifically produced between the permanent magnets 42 with which the position control means 30 and 35 were equipped with by the on-off control of the transistor components 15 and 16, and the micro mirror sections 43 and 42 were equipped in the current by a sink and the electromagnetic force which this generates with the position control means 30, 35, and 32.
[0018] In an example 1, the micro mirror sections 43 and 42 consist of stanchions 42 been [stanchions / it] united and prepared in the lower part of the micro mirror body 43 and the micro mirror body 43, and this stanchion 42 consists of a permanent magnet. And the stanchion 42 is arranged free [migration] near the position control means 30, 35, and 32. Moreover, the guide section 44 for restricting a motion of the micro mirror section is formed near the micro mirror body 43.
[0019] Position control of the micro mirror section is performed by vertical movement of the micro mirror section to a position control means in an example 1. In drawing 1 , the micro mirror section illustrated the condition of being in the location most distant from the position control means.
[0020] Again or the digital micro mirror device of this invention The transistor components 15 and 16 typical to drawing 1 formed in the (b) semi-conductor substrate 10 as a part was shown in a

sectional view, The position control means 30, 35, and 32 which were established on the (b) transistor component 15 and the insulating layer 20 formed on 16, and were electrically connected to the transistor component, Consist of the micro mirror body 43 and a stanchion 42, and the micro mirror body 43 is arranged on the guide layer 40 formed on the position control means. (Ha) the micro mirror sections 43 and 42 by which the stanchion 42 is contained free [migration] by hole 40A prepared in the guide layer 40, and the location of a stanchion 42 is controlled by actuation of a position control means — since — two or more constituted micro mirror components are arranged, and it changes.
[0021] The principle of operation of the micro mirror component of this invention is shown in drawing 2 . If the transistor components 15 and 16 are in the condition of OFF as shown in (A) of drawing 2 , the current is not flowing for the position control means connected to the transistor component. Therefore, electromagnetic force does not occur for the position control means 30, 32, and 35, but it is put on distance with fixed micro mirror section and position control means with the attraction committed between the permanent magnet 42 with which the micro mirror section was equipped, and this position control means. Consequently, the light which carried out incidence to the micro mirror section is injected in the predetermined direction. The light injected from the micro mirror section is interrupted by the shield which has opening prepared between the digital micro mirror device and the screen, and does not reach a screen.
[0022] If a transistor component is made into an ON state as shown in (B) of drawing 2 , a current will flow for the position control means connected to the transistor components 15 and 16, and electromagnetic force will occur for the position control means 30, 32, and 35. According to the repulsive force committed between the permanent magnet 42 with which the micro mirror section was equipped, and this position control means, the micro mirror section moves in the direction which separates from a position control means. Consequently, the injection direction of the light which carried out incidence to the micro mirror section changes from injection before actuation of a position control means. The light injected from the micro mirror section passes opening of the shield formed between the digital micro mirror device and the screen, and reaches a screen. In addition, it is good even if contrary to the above-mentioned explanation in the attainment condition to the screen of the light in the on-off condition of a transistor component.
[0023] In projecting an image on a screen, it carries out incidence of the color filter of RGB of the disk mold which rotates the light injected from the light source with the rotational speed of for example, 3600rpm to through and the digital micro mirror device of this invention. A white light is changed into three colors of RGB by rotating the color filter of a disk mold. The light of this RGB is reflected in the micro mirror section of a digital micro mirror device. And only the light in which the transistor component was reflected in the micro mirror section of the micro mirror component in an ON state (it is an OFF state depending on a configuration) reaches a screen through a projection lens. By carrying out time sharing of the display time of RGB, it is possible to control gradation.
[0024] Hereafter, the production approach of the digital micro mirror device of the example 1 shown in drawing 1 is explained with reference to typical drawing 3 which is sectional views a part, such as a semi-conductor substrate, - drawing 6 .
[0025] [Process -100] Based on the conventional approach, a MOS transistor component is first produced to the silicon semi-conductor substrate 10 (refer to (A) of drawing 3). Therefore, after first forming the component isolation region 11 which changes from SiO2 to the silicon semi-conductor substrate 10 by the conventional approach, the front face of the silicon semi-conductor substrate 10 is oxidized, and gate oxide 12 is formed. Subsequently, after making a polish recon layer deposit on the whole surface with a CVD method for example, with a photolithography technique and a dry etching technique, a polish recon layer is removed alternatively and the gate electrode 13 is formed. Then, the impurity ion implantation for forming LDD structure by the conventional approach is performed, and, subsequently to the side attachment wall of a gate electrode, the gate sidewall 14 which consists of SiO2 is formed. In this way, the gate polar zone 15 which consisted of the gate electrodes 13 and the gate sidewalls 14 which consist of gate oxide 12 and polish recon can be formed. Then, an impurity ion implantation is performed and the source drain field 16 is formed in the silicon semi-conductor substrate 10. Each of these processes can be performed based on a well-known approach.
[0026] The position control means electrically connected to the MOS transistor component is formed

above a MOS transistor component through an insulating layer after that [[process -110]].
[0027] [Process-110A] Therefore, first, it changes from SiO2 to the whole surface, and the insulating layer 20 with a thickness of 0.5 micrometers is formed in it with a CVD method. The conditions of a CVD method are illustrated below.
Gas used: TEOS=50sccm substrate temperature: 720-degreeC pressure : 40Pa [0028] In addition, the ingredient which constitutes an insulating layer 20 is not limited to SiO2, but can mention what carried out the laminating of other well-known insulating material, for example, BPSG, PSG and BSG, AsSG, PbSG, SbSG, SOG, SiON, SiN(s), or these insulator layers.
[0029] A photolithography technique and a dry etching technique are used for the upper insulating layer 20 of [process-110B], next the source drain field 16, and opening 21 is formed. The conditions of dry etching can be carried out as follows.
Gas used : C4F8=50sccmRF power: 1200W pressure : 2Pa [0030] The inside of opening 21 is embedded with a metal wiring material after that [[process-110C]]. Therefore, Ti and the TiN layer 22 are made to deposit from the bottom on the insulating layer 20 including the inside of opening 21 first using a spatter. This TiN/Ti layer achieves the function as the so-called barrier metal layer and a contact resistance reduction layer. Subsequently, for example, the tungsten (W) layer 23 is made to deposit on the TiN/Ti layer 22 including the inside of opening 21 using the so-called blanket tungsten CVD method. Then, the tungsten layer and TiN/Ti layer on an insulating layer 20 are removed, and only the inside of opening 21 is embedded in the TiN/Ti layer 22 and the tungsten layer 23 (refer to (B) of drawing 3). The etchback conditions of a tungsten layer and a TiN/Ti layer are illustrated below in the membrane formation conditions of Ti layer and a TiN layer, the membrane formation conditions of the tungsten layer by the blanket tungsten CVD method, and a list.
Membrane formation condition use gas of Ti layer : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : Membrane formation condition use gas of 30nmTiN layers : Ar/N2=40 / 70sccm power : 5kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : Membrane formation condition use gas of W layers by 70nm blanket tungsten CVD method : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : Condition use gas of 0.4-micrometer etchback : SF6=50sccm microwave power : 850WRF power : 150W pressure : 1.33Pa [0031] A position control means is formed on an insulating layer 20 after that [[process-110D]]. Therefore, the 1st conductive layer 30 which consists of aluminum or an aluminum system alloy (it may name generically and may be hereafter called aluminum system alloy) is first formed in the whole surface by the spatter. The formation conditions of the 1st conductive layer 30 are illustrated below.
Gas used : Ar=40sccm power : 22.5kW membrane formation temperature : 150-degreeC pressure : 0.47Pa thickness : Various aluminium alloys, such as pure aluminium, aluminum-Si, aluminum-Cu, aluminum-Si-Cu, aluminum-germanium, and aluminum-Si-germanium, can be illustrated as 0.3 micrometers and an aluminum system alloy.
[0032] Patterning of the 1st conductive layer 30 is carried out to a desired flat-surface configuration after that [[process-110E]] using a photolithography technique and a dry etching technique. Dry etching conditions can be carried out as follows.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa [0033] In addition, after skipping the process which embeds opening 21 in the tungsten layer 23 with a blanket tungsten CVD method and making aluminum system alloy layer deposit in a spatter on a TiN layer / Ti layer 22, the 1st conductive layer 30 by which embedded the inside of opening 21 with aluminum system alloy, and patterning was carried out collectively can also be obtained by removing alternatively aluminum system alloy layer and the TiN/Ti layer 22 on an insulating layer 20.
[0034] Instead of aluminum system alloy which constitutes the 1st conductive layer 30, metal wiring materials, such as W, Cu, and Ag, can be used. Moreover, the formation approach of these metal wiring materials is not limited to a spatter, for example, can also use a CVD method.
[0035] [Process-110F], next bias ECR The 1st flat layer insulation layer 31 which consists of SiN is formed in the whole surface with a CVD method on the whole surface (refer to (C) of drawing 3). The formation conditions of the 1st layer insulation layer 31 are illustrated below.
Gas used : SiH4/N2O=21/35sccm microwave power : 1000WRF power : 300W membrane formation temperature : 450-degreeC pressure : 0.01Pa [0036] The heart (core) layer 32 which consists of iron

is formed by the spatter on the 1st layer insulation layer 31 after that [[process-110G]]. The membrane formation conditions of a core layer 32 are illustrated below.
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 70nm [0037] In addition, Co, nickel, etc. can also constitute a core layer 32 from ferromagnetic ingredients, such as an alloy of these ingredients, and an oxide, instead of iron.
[0038] Patterning of the core layer 32 is carried out to a desired flat-surface configuration (for example, rectangle) using [process-110H] next a photolithography technique, and a dry etching technique (refer to (A) of drawing 4). Dry etching conditions can be carried out as follows.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa substrate temperature : 350-degreeC [0039] After that [[process-110I]], bias ECR The 2nd flat layer insulation layer 33 which consists of SiN is formed in the whole surface with a CVD method on the whole surface. The formation conditions of the 2nd layer insulation layer 33 can be made to be the same as that of the formation conditions of the 1st layer insulation layer 31. Subsequently, opening 34 is formed in the 2nd layer insulation layer 33 using a photolithography technique and a dry etching technique. Dry etching conditions are illustrated below.
Gas used : C4F8=50sccmRF power : 1200W pressure : 2Pa [0040] In addition, the ingredient which constitutes the 1st layer insulation layer 31 or the 2nd layer insulation layer 33 is not limited to SiN, but can mention what carried out the laminating of other well-known insulating materials 2, for example, SiO, BPSG, PSG and BSG, AsSG, PbSG, SbSG, SOG, SiON(s), or these insulator layers.
[0041] In this way, the structure shown in (B) of drawing 4 can be acquired. In addition, in (B) of drawing 4 , although it is illustrated as if opening was formed also in the core layer 32, opening is not formed in the core layer 32 in fact. Opening 34 is formed only in the 2nd layer insulation layer 33. Moreover, in (B) of drawing 4 , although the condition that opening 34 was formed in the part on the right-hand side of [each] the field of the 1st conductive layer 30 by which patterning was carried out was shown, opening (not shown) is formed also in the part on the left-hand side of [each] the 1st conductive layer 30 by which patterning was carried out in fact.
[0042] For example, a TiN layer (not shown) is formed on the [process-110J], next 2nd layer insulation layer 33 which include the inside of opening 34 in a spatter, and the 2nd conductive layer 35 which consists of a tungsten is further formed with a blanket tungsten CVD method on it. The membrane formation conditions of a TiN layer can be made to be the same as that of the membrane formation conditions of the TiN layer of [process-11C]. Membrane formation condition use gas of the 2nd conductive layer : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : 0.3 micrometers [0043] Patterning of the 2nd conductive layer 35 and a TiN layer is performed on the etchback conditions of [process-110C], and the same conditions after that [[process-110K]] using a photolithography technique and a dry etching technique.
[0044] In addition, the 2nd conductive layer 35 can also be formed instead of formation of the 2nd conductive layer 35 by the blanket tungsten CVD method by forming other metal wiring materials with a spatter or a CVD method on the 2nd layer insulation layer 33 including the inside of opening 34.
[0045] [Process-110L] Further, after making the 3rd layer insulation layer 36 which consists of BPSG deposit on the whole surface, flattening processing of the 3rd layer insulation layer 36 by heating is performed. In this way, the structure shown in (A) of drawing 5 can be acquired. The membrane formation conditions of the 3rd layer insulation layer 36 are illustrated below.
Gas used : SiH4/PH3/B-2H6/O2/N2=80/7/7/1000/32000sccm membrane formation temperature : 400-degreeC pressure : 1.0x105Pa thickness : 0.15 micrometers [0046] In addition, the ingredient which constitutes the 3rd layer insulation layer 36 is not limited to BPSG, but if it is an ingredient which is not etched into coincidence in case it etches the sacrifice layer formed behind, it can use any well-known insulating materials.
[0047] In this way, the position control means which is a kind of electromagnet which consisted of the 1st conductive layer 30 which is equivalent to a coil at the core layer 32 which consists of iron, for example and is equivalent to the core part (core section) of an electromagnet, and a list, and the 2nd conductive layer 35 (these layers 30 and 35 are electrically connected one by one through opening 34 and opening which is not illustrated) is completed. The end (a part of 1st conductive layer 30 by which patterning was carried out) of a coil is electrically connected with the source drain field 16 of a MOS transistor component through the TiN/Ti layer 22 and the tungsten layer 23 which were

embedded in opening 21. the edge (in or the case other edges of the 1st conductive layer 30) of the 2nd conductive layer 35 which is the other end of a coil on the other hand — for example, it is grounded (not shown). By this, if a MOS transistor component is turned on, a current will flow in the coil which consisted of the 1st conductive layer 30 and 2nd conductive layer 35, and a field will occur.
[0048] [A process −120], next the micro mirror sections 43 and 42 are formed above the position control means 30, 35, and 32.
[0049] [Process−120A] Therefore, the guide layer 40 which consists of polish recon is first formed in the whole surface. The CVD formation conditions of the guide layer 40 are illustrated below.
Gas used : SiH4/helium=500 / 50sccm pressure : 80Pa membrane formation temperature : 400−degreeC thickness : 0.8 micrometers [0050] In addition, if it is the ingredient which is not etched into coincidence and is the ingredient which does not reflect light in case the sacrifice layer formed behind is etched instead of polish recon as an ingredient which constitutes a guide layer, any well−known ingredients can be used.
[0051] Hole 40A is formed in the guide layer 40 which consists of polish recon with a photolithography technique and a dry etching technique after that [[process−120B]]. In addition, the stanchion behind formed in this hole 40A is contained. The conditions of dry etching can be made to be the same as that of [process−110I].
[0052] [Process−120C] Subsequently the sacrifice layer (detached core) 41 which consists of SiO2 is formed with the CVD method of the conditions illustrated below all over the guide layer 40 containing hole 40A (refer to (B) of drawing 5).
Gas used : SiH4/O2/N2=80/1000/32000sccm membrane formation temperature : 400−degreeC pressure : 1.0x105Pa thickness : 50nm [0053] An iron layer is made to deposit on the whole surface in the spatter of the conditions of [process−120D] after that, for example, the following.
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150−degreeC thickness : 1.0 micrometers [0054] The magnet prepared independently is brought close to an iron layer, and an iron layer is made to magnetize in [process−120E] and this condition. Then, using a photolithography technique and a dry etching technique, patterning of the iron layer is carried out and it leaves an iron layer into hole 40A. Dry etching conditions can be made to be the same as that of [process−110H]. In this way, the structure shown in (A) of drawing 6 can be acquired. The iron layer left behind into hole 40A is equivalent to a stanchion 42. Moreover, the stanchion 42 which consists of an iron layer is permanent−magnet−ized.
[0055] For example, aluminum system alloy layer is formed by the spatter on [process−120F] next the sacrifice layer 41, and a stanchion 42. The formation conditions of aluminum system alloy layer are illustrated below.
Gas used : Ar=40sccm power : 22.5kW membrane formation temperature : 500−degreeC pressure : 0.47Pa thickness : 0.3 micrometers [0056] After that [[process−120G]], using a photolithography technique and a dry etching technique, patterning of the aluminum system alloy layer is carried out, and the micro mirror body 43 which consists of aluminum system alloy layer is formed. The conditions of dry etching can be made to be the same as that of [process−110E]. In this way, the structure shown in (B) of drawing 6 can be acquired.
[0057] After forming opening in [process−120H], next the about 43 micro mirror body sacrifice layer 41, for example, a polish recon layer is made to deposit on the whole surface. And a polish recon layer is removed alternatively and perpendicular wall 44A which constitutes the guide section is formed from a polish recon layer. Next, the sacrifice layer 45 which consists, for example of SiO2 is made to deposit on the whole surface (refer to (A) of drawing 7). Then, a polish recon layer is made to deposit on the whole surface again, this polish recon layer is removed alternatively, and horizontal height 44B which constitutes the guide section is formed (refer to (B) of drawing 7).
[0058] The sacrifice layers 45 and 41 which change from SiO2 to the [process−120I] last by the dry etching method are removed. The conditions of dry etching are illustrated below.
Gas used : CF4=100sccmRF power: 50W pressure : 6Pa [0059] In this way, the micro mirror component of the structure shown in drawing 1 is producible.
[0060] (Example 2) An example 2 is deformation of an example 1 and the structure of the micro mirror section is different from an example 1. namely, the 2nd voice by which the united stanchion is

prepared in the lower part of the micro mirror section, as for the example 2, the permanent magnet layer 50 is formed in the pars basilaris ossis occipitalis (it sets in the example 2 and is the whole surface of the external surface of a stanchion) of the stanchion which consists of this polish recon, and the stanchion is arranged free [migration] near the position control means — it is related like. Moreover, the micro mirror body in the micro mirror section is the two-layer structure of aluminum system alloy layer 52 and the tungsten layer 53, and light is reflected by the tungsten layer 53.
[0061] In production of the digital micro mirror device of an example 2, formation of a position control means, i.e., the formation process of the 3rd layer insulation layer 36, can presuppose that it is the same as that of an example 1. So, only the formation approach of the micro mirror section is hereafter explained with reference to drawing 8 and drawing 9 .
[0062] [Process-200A] After forming the guide layer 40 which consists of polish recon like [process-120A] - [process-120C] on the 3rd layer insulation layer 36, hole 40A is formed in the guide layer 40. [of an example 1] Subsequently, the sacrifice layer (detached core) 41 which consists of SiO2 all over the guide layer 40 containing hole 40A is formed with a CVD method (refer to (A) of drawing 8).
[0063] An iron layer is made to deposit on the whole surface in the spatter of the conditions of [process-200B] after that, for example, the following. Hole 40A makes thickness of an iron layer the thickness which is not embedded by the iron layer.
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 70nm [0064] The magnet independently prepared in the state of [this] [process-200C] is brought close to an iron layer, an iron layer is magnetized, and an iron layer is permanent-magnet-ized.
[0065] After that [[process-200D]], using a photolithography technique and a dry etching technique, patterning of the iron layer is carried out and it leaves an iron layer into hole 40A. Dry etching conditions can be made to be the same as that of [process-110H] of an example 1. In this way, the permanent magnet layer 50 can be formed in the pars basilaris ossis occipitalis and the side-attachment-wall section of hole 40A.
[0066] [Process-200E] Subsequently to the whole surface, the polish recon layer 51 is formed. The CVD formation conditions of the polish recon layer 51 can be made to be the same as that of [process-120A] of an example 1.
[0067] After that [[process-200F]], whole surface etchback of the polish recon layer 51 is carried out, and it leaves the polish recon layer 51 only in the crevice of the permanent magnet layer 50 formed in the inside of hole 40A. In this way, the structure shown in (B) of drawing 8 can be acquired. The permanent magnet layer 50 and the polish recon layer 51 which were left behind into hole 40A are equivalent to a stanchion. In other words, even if there are few stanchions, the permanent magnet layer 50 is formed in a pars basilaris ossis occipitalis (it sets in the example 2 and they are all the external surface of a stanchion). The etchback conditions of a polish recon layer are illustrated below.
Gas used : C2Cl3F3/SF6=65/5sccm microwave power : 850WRF power : 150W pressure : 1.33Pa
[0068] aluminum system alloy layer 52 is formed on the whole surface on the same conditions as [process-120F] of an example 1 after that [[process-200G]]. Next, the tungsten layer 53 is formed on aluminum system alloy layer 52 with the CVD method illustrated below.
Gas used : WF6/H2=95 / 550sccm membrane formation temperature : 450-degreeC pressure : 1.1x104Pa thickness : 30nm [0069] The tungsten layer 53 and aluminum system alloy layer 52 are etched into a desired pattern using [process-200H] next a photolithography technique, and a dry etching technique (refer to (C) of drawing 8). Etching conditions are illustrated below.
Gas used : BCl3/Cl2=60 / 90sccm microwave power : 1000WRF power : 50W pressure : 0.016Pa
[0070] The tungsten layer 54 with a thickness of 100nm is made to deposit on the whole surface with the CVD method of the same conditions as [process-200G] again after that [[process-200I]]. And etchback of the tungsten layer 54 is carried out on the same conditions as [process-110C] of an example 1. In this way, the structure shown in (A) of drawing 9 can be acquired. The top face and the side face are covered with the tungsten layers 53 and 54, and aluminum system alloy layer 52 can give high dependability to a micro mirror body.
[0071] the dilution fluoric acid solution (HF:H2O=5:100) after forming the guide section (not shown) near the micro mirror body 43 by the same approach as [process-120H] of an example 1 after that

[[process-200J]] — for example, sacrifice layer 41 grade is removed by being immersed for 5 minutes. In this way, the micro mirror section of the structure shown in (B) of drawing 9 is producible. In addition, finally the tungsten layers 53 and 54 of aluminum system alloy layer 52 top and a side attachment wall may be removed by the plasma-etching method illustrated below.
Gas used : CF4=100sccmRF power: 50W pressure : 6Pa [0072] (Example 3) An example 3 is also deformation of an example 1 and the structure of the micro mirror section is different from an example 1. namely, the 3rd voice by which the united stanchion is prepared in the lower part of the micro mirror section, as for the example 3, the base (specifically base of a micro mirror body) of the micro mirror section and the external surface of a stanchion are equipped with the permanent magnet layer, and this stanchion is arranged free [migration] near the position control means — it is related like. Moreover, the micro mirror body in the micro mirror section is the two-layer structure of the polish recon layer 62 and aluminum system alloy layer 63, and light is reflected by aluminum system alloy layer 63. Although the sacrifice layer was formed from SiO2 in the example 1, in the example 3, the sacrifice layer was formed from the organic resist ingredient. Moreover, a permanent magnet layer consists of cobalt (Co).
[0073] In production of the digital micro mirror device of an example 3, formation of a position control means, i.e., the formation process of the 3rd layer insulation layer 36, can presuppose that it is the same as that of an example 1. So, only the formation approach of the micro mirror section is hereafter explained with reference to drawing 10 and drawing 11 .
[0074] [Process-300A] After forming the guide layer 40 which consists of polish recon like [process-120A] - [process-120B] on the 3rd layer insulation layer 36, hole 40A is formed in a guide layer. [of an example 1] Subsequently, the sacrifice layer (detached core) 60 which consists of an organic resist ingredient all over the guide layer 40 containing hole 40A is formed on a spin coat (refer to (A) of drawing 10). The formation conditions of the sacrifice layer 60 are illustrated below.
Use resist ingredient : OFPR 30cp spreading coating-machine engine speed : Baking after 2000rpm spreading : 100-degreeC [0075] The Co layer 61 is made to deposit all over the upper [of the sacrifice layer 60 which includes the inside of hole 40A in the spatter of the conditions of [process-300B] after that, for example, the following,].
Gas used : Ar=100sccm power : 4kW pressure : 0.47Pa membrane formation temperature : 150-degreeC thickness : 0.3 micrometers [0076] The magnet independently prepared in the state of [this] [process-300C] is brought close to the Co layer 61, the Co layer 61 is magnetized, and the Co layer 61 is permanent-magnet-ized. That is, the Co layer 61 turns into a permanent magnet layer.

[0077] The polish recon layer 62 with a thickness of 0.5 micrometers is formed all over after that [[process-300D]]. The CVD formation conditions of the polish recon layer 62 can be made to be the same as that of [process-120A] of an example 1, and abbreviation. In addition, the polish recon layer 62 is deposited also in the crevice of the Co layer 61 deposited in hole 40A, and this polish recon layer is equivalent to a stanchion.
[0078] aluminum system alloy layer 63 is formed on the whole surface on the same conditions as [process-120F] of an example 1 after that [[process-300E]]. In this way, the structure shown in (B) of drawing 10 can be acquired. It has the permanent magnet layer which changes from the Co layer 61 to the base of the micro mirror sections 62 and 63, and the external surface of a stanchion.
[0079] Patterning is carried out using [process-300F] next a photolithography technique, and a dry etching technique on the conditions which illustrate aluminum system alloy layer 63, the polish recon layer 62, and the Co layer 61 below.
patterning use gas [of aluminum system alloy layer]: — patterning use gas [ ] of a 50W pressure : 0.016Pa polish recon layer — : C4F8/Ar — =50/10sccmRF power : 1200W Pressure : [ ] — in addition, patterning of the 2Pa of the Co layers 61 can be carried out by the over etching after the dry etching of the polish recon layer 62. : BCl3/Cl2=60 / 90sccm microwave power: 1000WRF power [0080] Oxygen plasma-asher processing of the conditions of [process-300G] after that, for example, the following, is performed, and the sacrifice layer 60 which consists of an organic resist ingredient is removed.
Gas used : O2=20sccmRF plasma : 200V pressure : The sacrifice layer 60 is completely removed by the fuming nitric acid after 1atm oxygen plasma-asher processing.

[0081] As mentioned above, although the digital micro mirror device of this invention was explained based on the desirable example, this invention is not limited to these examples. The various membrane formation conditions of having explained in each example are instantiation, and can be changed suitably. The membrane formation approach can also replace a spatter and a CVD method suitably.

[0082] In an example, although the position control of the micro mirror section was chiefly based on the vertical movement to a position control means, it may perform position control (include-angle control) of the micro mirror section to a position control means by what the micro mirror section is rotated for (an include-angle variation rate is carried out). In this case, what is necessary is just to, make different the clearance between horizontal height 44B and the guide layers 40 which constitute the guide section 44 for example the left-hand side and on the right-hand side of drawing 1 , and the guide section 44 may be formed near the one side of the micro mirror section. [of the micro mirror section] . Or what is necessary is to prepare one height or the pin section in the side attachment wall of a stanchion, and just to form the hole which engages with the height or the pin section concerning the side attachment wall of hole 40A gently again. The structure of a position control means is instantiation and can change structure suitably.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the typical sectional view of the micro mirror component in the digital micro mirror device of an example 1.
[Drawing 2] It is a schematic diagram explaining the principle of operation of the digital micro mirror device of this invention.
[Drawing 3] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 1.
[Drawing 4] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 1 following on drawing 3 .
[Drawing 5] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 1 following on drawing 4 .
[Drawing 6] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 1 following on drawing 5 .
[Drawing 7] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 1 following on drawing 6 .
[Drawing 8] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 2.
[Drawing 9] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 2 following on drawing 8 .
[Drawing 10] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 3.
[Drawing 11] It is a typical sectional view for explaining the production approach of the micro mirror component in the digital micro mirror device of an example 2 following on drawing 10 .
[Drawing 12] They are a schematic diagram explaining the principle of operation of the conventional digital micro mirror device, and the typical sectional view of the micro mirror component in the conventional digital micro mirror device.
[Description of Notations]
10 Silicon Semi-conductor Substrate
11 Component Isolation Region
12 Gate Oxide
13 Gate Electrode
14 Gate Sidewall
15 Gate Polar Zone
16 Source Drain Field
20 Insulating Layer
21 Opening
22 TiN/Ti Layer
23 Tungsten Layer
30 35 Conductive layer
31, 33, 36 Layer insulation layer
32 Heart (Core) Layer

34 Opening
40 Guide Layer
40A Hole
41 60 Sacrifice layer (detached core)
42 Stanchion
43 Micro Mirror Body
44 Guide Section
50 Permanent Magnet Layer
51 Polish Recon Layer
52 Aluminum System Alloy Layer
53 54 Tungsten layer
61 Co Layer
62 Polish Recon Layer
63 Aluminum System Alloy Layer

[Translation done.]

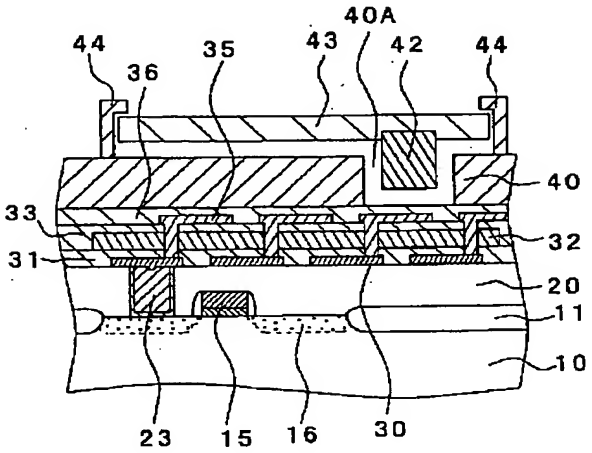
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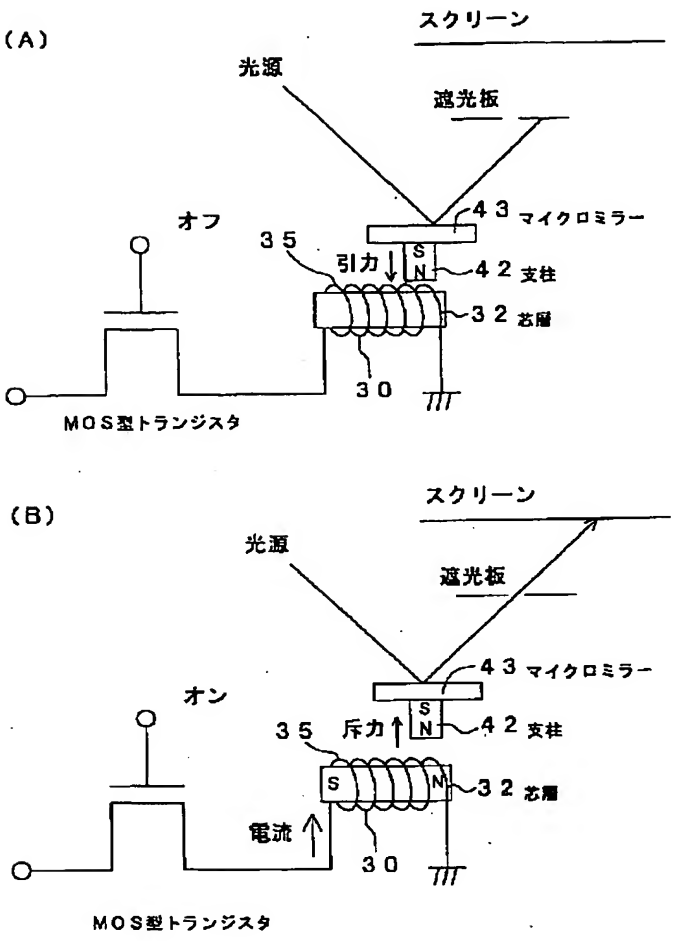
DRAWINGS

[Drawing 1]
（実施例１）



[Drawing 2]

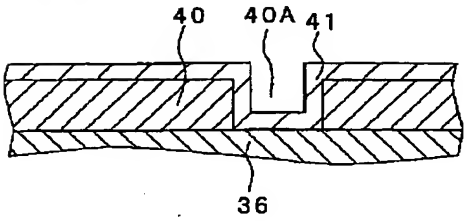
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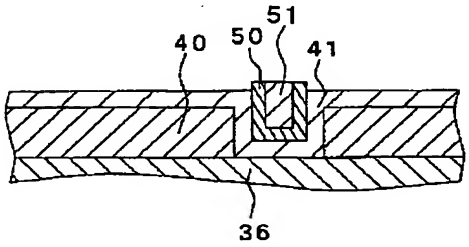
[Drawing 8]

（実施例２）　その１

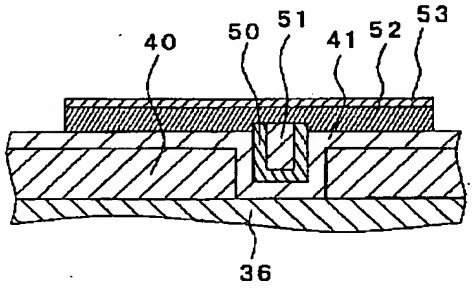
(A)



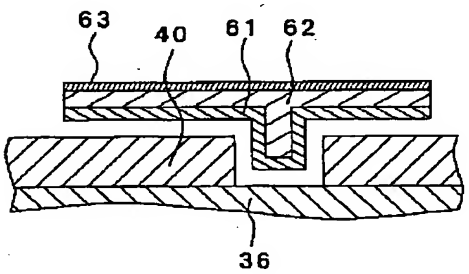
(B)



(C)

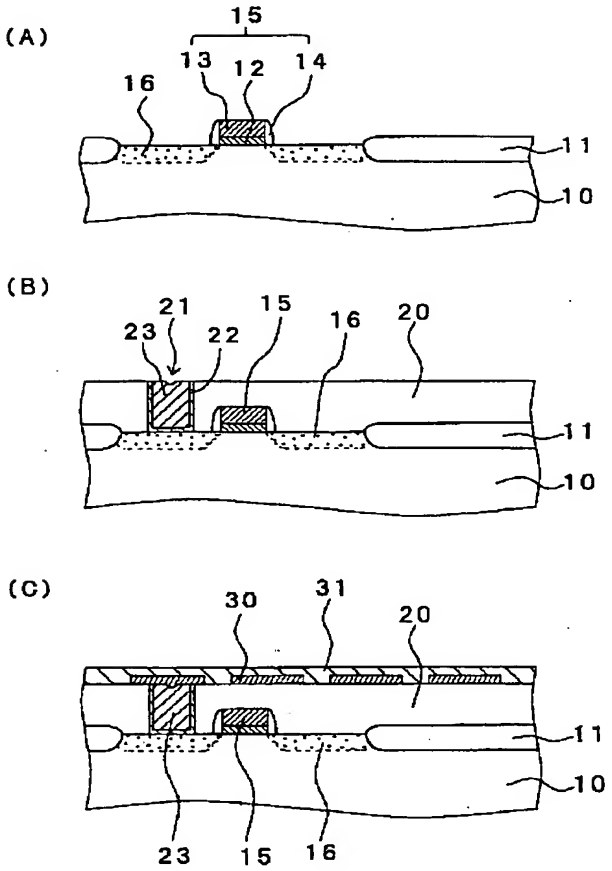


[Drawing 11]
（実施例３）　その２



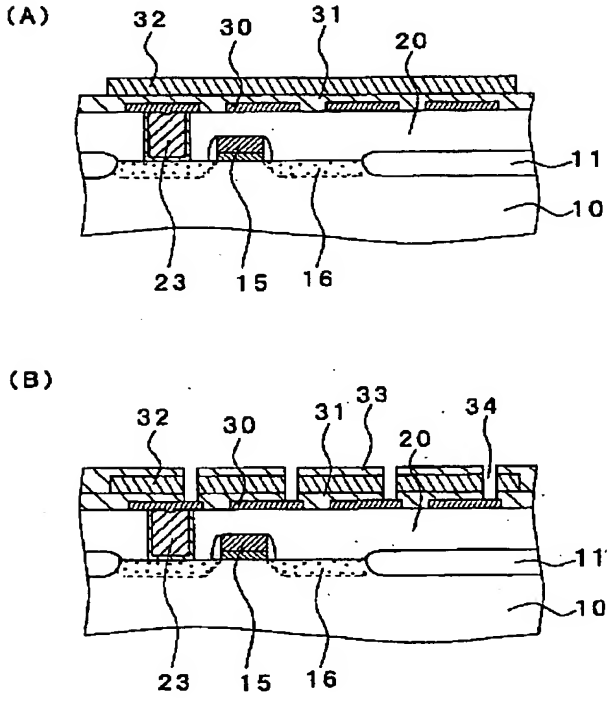
[Drawing 3]

（実施例１）　その１



[Drawing 4]

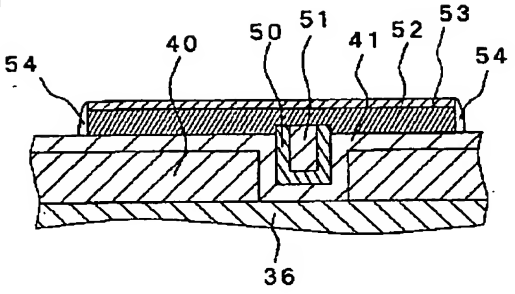
（実施例１）　その２



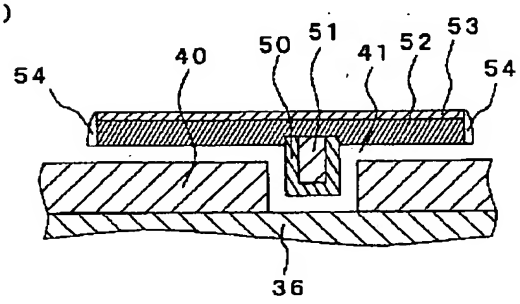
[Drawing 9]

（実施例2）　その2

(A)



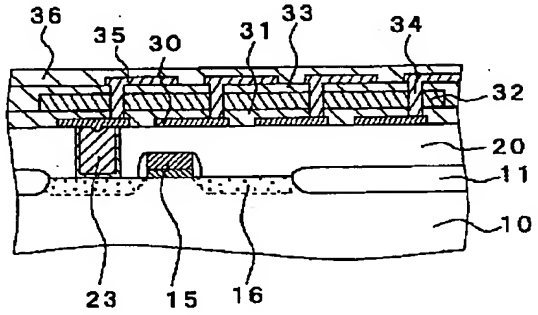
(B)



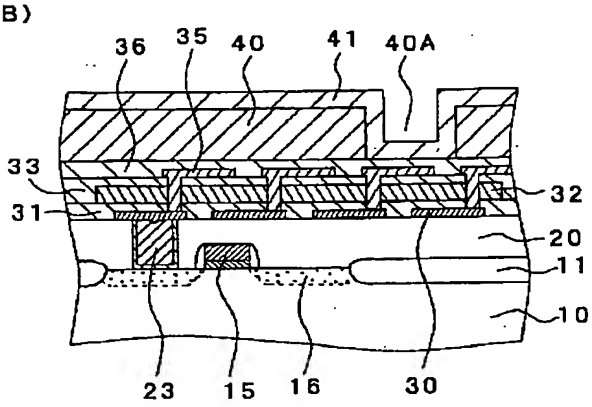
[Drawing 5]

（実施例1）　その3

(A)



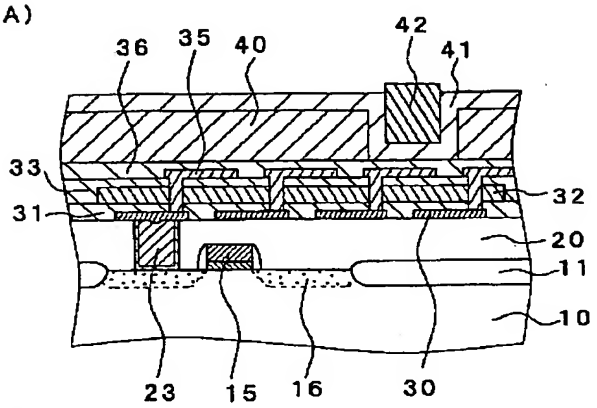
(B)



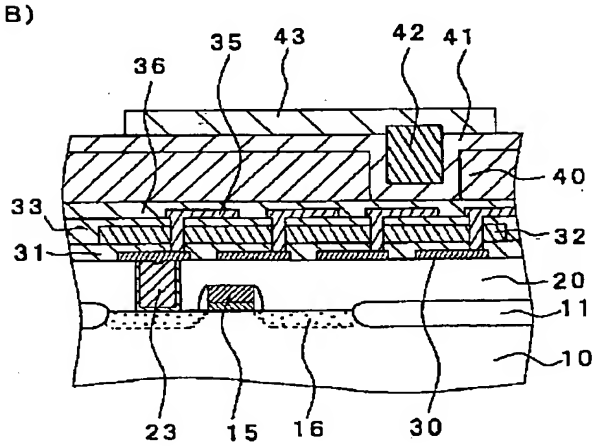
[Drawing 6]

（実施例１）　その４

(A)

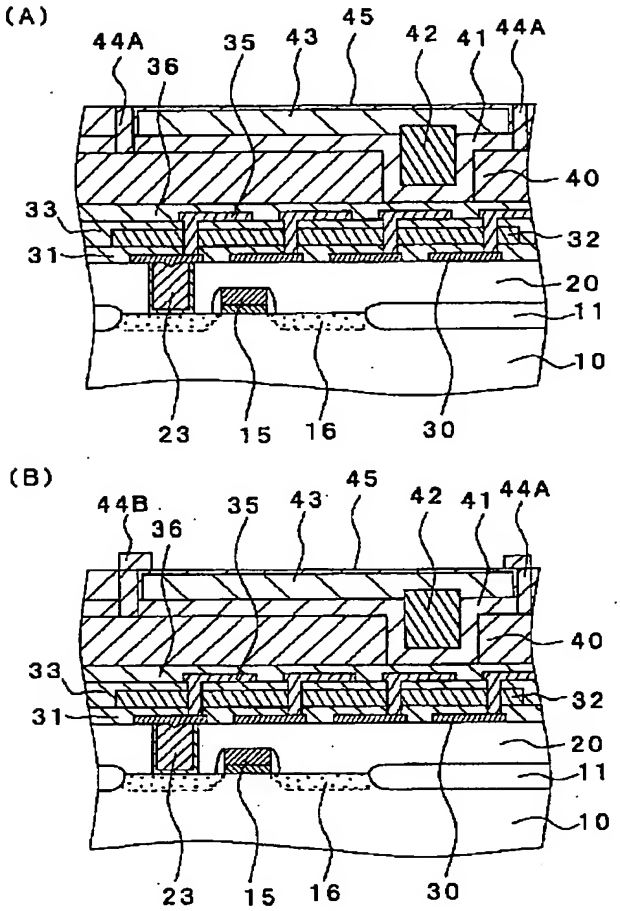


(B)



[Drawing 7]

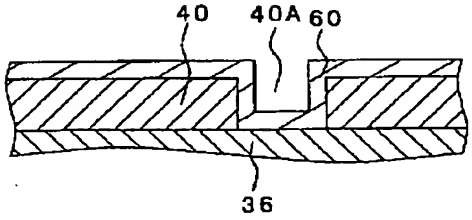
（実施例１）　その５



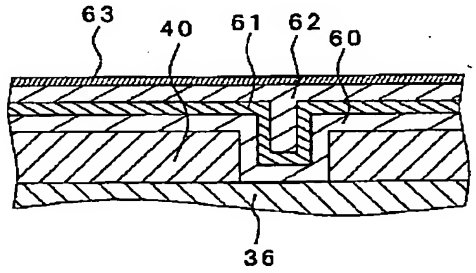
[Drawing 10]

（実施例３）　その１

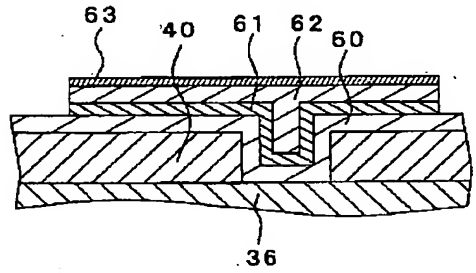
（A）



（B）



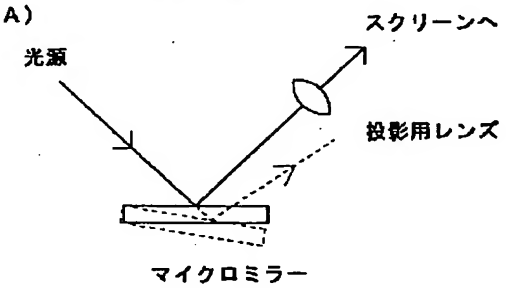
（C）



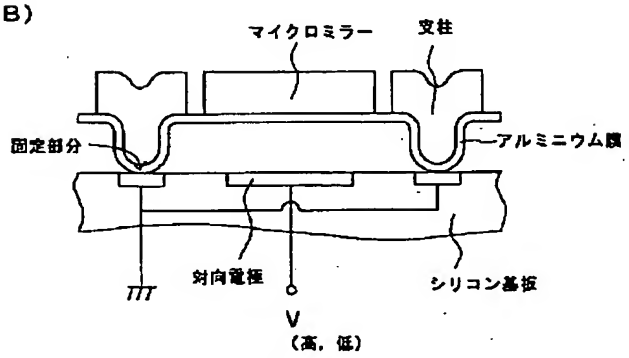
[Drawing 12]

（従来の技術）

（A）



（B）



[Translation done.]

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3.In the drawings, any words are not translated.

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 2nd partition of the 6th section
[Publication date] June 29, Heisei 13 (2001. 6.29)

[Publication No.] JP,7-306368,A
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[Application number] Japanese Patent Application No. 6-123296
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G02B 26/08
H04N 5/74

[FI]

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H04N 5/74 A

[Procedure revision]
[Filing Date] June 16, Heisei 12 (2000. 6.16)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] 0082
[Method of Amendment] Modification
[Proposed Amendment]
[0082] In an example, although the position control of the micro mirror section was chiefly based on the vertical movement to a position control means, it may perform position control (include-angle control) of the micro mirror section to a position control means by what the micro mirror section is rotated for (an include-angle variation rate is carried out). In this case, what is necessary is just to, make different the clearance between horizontal height 44B and the guide layers 40 which constitute the guide section 44 for example the left-hand side and on the right-hand side of drawing 1, and the guide section 44 may be formed near the one side of the micro mirror section. [of the micro mirror section] Or what is necessary is to prepare one height or the pin section in the side attachment wall of a stanchion, and just to form the hole which engages with the height or the pin section concerning the side attachment wall of hole 40A gently again. The structure of a position control means is instantiation and can change structure suitably.

[Translation done.]

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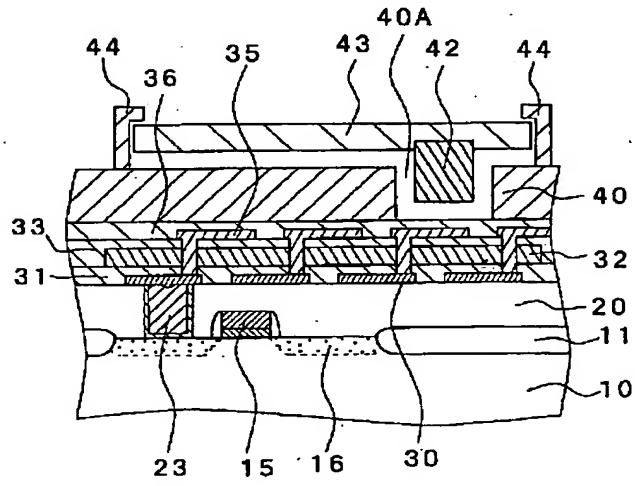
(54)【発明の名称】　デジタルマイクロミラーデバイス

(57)【要約】

【目的】高い信頼性と長い寿命を有するデジタルマイクロミラーデバイスを提供する。

【構成】デジタルマイクロミラーデバイスは、（イ）１つのマイクロミラー部４３，４２と、（ロ）１つのマイクロミラー部に対応して設けられた、マイクロミラー部の位置を制御するための１つの位置制御手段３０，３２，３５と、（ハ）位置制御手段を制御するための１つのトランジスタ素子１５，１６、から構成されたマイクロミラー素子を複数配列して成り、そして、マイクロミラー部は位置制御手段に対して移動自在に取り付けられている。

（実施例１）



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【特許請求の範囲】

【請求項１】（イ）１つのマイクロミラー部と、

（ロ）該１つのマイクロミラー部に対応して設けられた、マイクロミラー部の位置を制御するための１つの位置制御手段と、

（ハ）該位置制御手段を制御するための１つのトランジスタ素子、

から構成されたマイクロミラー素子を複数配列して成り、そして、該マイクロミラー部は位置制御手段に対して移動自在に取り付けられていることを特徴とするデジタルマイクロミラーデバイス。

【請求項２】マイクロミラー部には永久磁石が備えられており、位置制御手段は電磁石から成りそしてトランジスタ素子に電気的に接続されており、トランジスタ素子の制御により位置制御手段が発生する電磁力によってマイクロミラー部の位置を制御することを特徴とする請求項１に記載のデジタルマイクロミラーデバイス。

【請求項３】マイクロミラー部の下部には一体となった支柱が設けられており、該支柱は永久磁石から成り、該支柱は位置制御手段の近傍に配置されていることを特徴とする請求項２に記載のデジタルマイクロミラーデバイス。

【請求項４】マイクロミラー部の下部には一体となった支柱が設けられており、該支柱の少なくとも底部に永久磁石層が設けられており、該支柱は位置制御手段の近傍に配置されていることを特徴とする請求項２に記載のデジタルマイクロミラーデバイス。

【請求項５】マイクロミラー部の下部には一体となった支柱が設けられており、該マイクロミラー部の底面及び支柱の外面に永久磁石層が備えられており、該支柱は位置制御手段の近傍に配置されていることを特徴とする請求項２に記載のデジタルマイクロミラーデバイス。

【請求項６】（イ）半導体基板に形成されたトランジスタ素子と、

（ロ）該トランジスタ素子上に形成された絶縁層の上に設けられ、トランジスタ素子に電気的に接続された位置制御手段と、

（ハ）マイクロミラー本体と支柱とから成り、位置制御手段の上に形成されたガイド層の上にマイクロミラー本体が配置され、ガイド層に設けられた穴部に支柱が移動自在に収納されており、位置制御手段の動作によって支柱の位置が制御されるところのマイクロミラー部、

から構成されたマイクロミラー素子を複数配列して成ることを特徴とするデジタルマイクロミラーデバイス。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、映像投影装置で用いられるデジタルマイクロミラーデバイスに関する。

【０００２】

【従来の技術】近年、テレビ放送等の高品質化に伴いテレビの大画面化が進行し、２９インチ以上の大画面ブラウン管を搭載したテレビ受像機が主流になりつつある。ところが、テレビ受像機が大画面化すると共にその重量が増大し、例えば、２９インチのテレビ受像機では総重量が６０ｋｇ以上にもなり、移動が困難となっている。ＨＤＶＳの一般放送も間近になってきているが、ＨＤＶＳ用のブラウン管を用いた受像機は更に大型化が進み、９０ｋｇ以上の大重量になっている。最早、このような重量になると、一度設置された受像機を後で移動させることが極めて困難となる。

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【０００３】これに対して、近年、液晶デバイスを用いた投影方式の表示装置が考案されている。かかる表示装置においては、光を液晶デバイスを透過させることで、液晶デバイス上に形成された画像が映像スクリーン上に投影される。このような表示装置においては重いブラウン管が必要なくなり、表示装置は照明用の光源と液晶デバイスから構成されるだけであり、表示装置は非常に軽くなる。この種の表示装置においては液晶デバイス内を光を透過させる必要がある。然るに、液晶デバイスの光透過率は数％と低く、スクリーン上に投影された映像が暗いという問題を有する。

【０００４】近年、新しい投影装置として、テキサスインスツルメンツ社からデジタルマイクロミラーデバイス（Digital Mirror Device）を用いた投影装置が提案されている。例えば、J.P. Sampsell, "An Overview of the Didital Micromirror Device (DMD) and Its Application to Projection Display", 1993 Society for Imformation Display International Symposium (SID '93) Digest of TechnicalPapers, pp 1012-1015, May 1993を参照のこと。この投影装置は、多数のＳＲＡＭの各々の上に鏡（マイクロミラー）を整列させた構造を有する。そして、これらの鏡にＲＧＢの光源からの光を入射する。そして、ＳＲＡＭからの信号に基づきそれぞれの鏡を動かし（回転させ）、鏡から射出される光の方向を変化させる。適切な方向にスクリーンを配置しておくことによって、鏡で反射された光をスクリーン上に投影させることができる。即ち、ＳＲＡＭに画像制御信号を入力することによって、スクリーン上に画像を映し出すことができる。この状態を模式的に図１２の（Ａ）に示す。

【０００５】

【発明が解決しようとする課題】デジタルマイクロミラーデバイスにおける各々の鏡の平面形状は矩形である。そして、鏡の四隅の内、一方の対角線上の２つの隅（便宜上、固定部分と呼ぶ）で鏡はシリコン基板上に固定されている。鏡の他の対角線上の２つの隅はフリーな状態に置かれている。一方の対角線に沿った１つの鏡の模式的な断面図を図１２の（Ｂ）に示す。各鏡はアルミニウム膜上に形成されており、空中に浮いた状態で２つの支柱によって支えられている。このデジタルマイクロミラ

ーデバイスにおける鏡を駆動する（即ち、鏡から射出される光の方向を変化させる）ために、アルミニウム膜に或る電位を与え、一方、鏡に対向した対向電極をアルミニウム膜と反対の電位にすることで、アルミニウム膜と電極の間にクーロン力を働かせる。これによって、固定部分を支点として鏡を回転させることができる。半導体基板に形成されたＳＲＡＭに電気的に接続された対向電極の電位を１，０（高，低）と変化させることでクーロン力を変化させ、鏡の回転制御を行う。

【０００６】鏡が駆動されるときアルミニウム膜には応力が加わる。即ち、アルミニウム膜から成る鏡の固定部分にねじれ等の負荷が加わる。その結果、この部分に金属疲労が発生し、鏡の固定部分を構成するアルミニウム膜が破損する。従って、鏡の固定部分の信頼性がデジタルマイクロミラーデバイスの信頼性を支配している。それ故、この固定部分の信頼性を向上させることが、デジタルマイクロミラーデバイスを用いた投影装置の実用化の鍵の１つである。また、微小な金属膜が空中に浮いた構造となっているため、接触などの物理的刺激に弱いという問題もある。

【０００７】従って、本発明の目的は、高い信頼性と長い寿命を有し、駆動回路が簡素化されたデジタルマイクロミラーデバイスを提供することにある。

【０００８】

【課題を解決するための手段】上記の目的を達成するための本発明のデジタルマイクロミラーデバイスは、

（イ）１つのマイクロミラー部と、（ロ）該１つのマイクロミラー部に対応して設けられた、マイクロミラー部の位置を制御するための１つの位置制御手段と、（ハ）該位置制御手段を制御するための１つのトランジスタ素子、から構成されたマイクロミラー素子を複数配列して成り、そして、該マイクロミラー部は位置制御手段に対して移動自在に取り付けられていることを特徴とする。

【０００９】マイクロミラー部の位置制御としては、位置制御手段とマイクロミラー部との間の距離の制御、位置制御手段に対するマイクロミラー部の角度の制御を挙げることができる。マイクロミラー部は位置制御手段に対して堅固に固定されてはいない。

【００１０】本発明のデジタルマイクロミラーデバイスにおいては、マイクロミラー部には永久磁石が備えられており、位置制御手段は電磁石から成りそしてトランジスタ素子に電気的に接続されており、トランジスタ素子の制御により位置制御手段が発生する電磁力によってマイクロミラー部の位置を制御する構成とすることができる。

【００１１】この場合、マイクロミラー部の下部には一体となった支柱が設けられており、該支柱は永久磁石から成り、該支柱は位置制御手段の近傍に配置されている第１の態様、あるいは、マイクロミラー部の下部には一体となった支柱が設けられており、該支柱の少なくとも

底部に永久磁石層が設けられており、該支柱は位置制御手段の近傍に配置されている第２の態様、更には又、マイクロミラー部の下部には一体となった支柱が設けられており、該マイクロミラー部の底面及び支柱の外面に永久磁石層が備えられており、該支柱は位置制御手段の近傍に配置されている第３の態様を挙げることができる。マイクロミラー部がマイクロミラー素子から脱落しないように、マイクロミラー素子にはガイド部を設けることが望ましい。

【００１２】あるいは又、上記の目的を達成するための本発明のデジタルマイクロミラーデバイスは、（イ）半導体基板に形成されたトランジスタ素子と、（ロ）該トランジスタ素子上に形成された絶縁層の上に設けられ、トランジスタ素子に電気的に接続された位置制御手段と、（ハ）マイクロミラー本体と支柱とから成り、位置制御手段の上に形成されたガイド層の上にマイクロミラー本体が配置され、ガイド層に設けられた穴部に支柱が移動自在に収納されており、位置制御手段の動作によって支柱の位置が制御されるところのマイクロミラー部、から構成されたマイクロミラー素子を複数配列して成ることを特徴とする。

【００１３】マイクロミラー部の光反射面は、適切な量の光を反射する材料ならば如何なる材料からも構成することができ、しかも単層であっても複数層であってもよいが、中でも、アルミニウム、アルミニウム合金、ニッケル、クロム、銅、銀等を用いることが好ましい。マイクロミラー部に備えられた永久磁石（あるいは永久磁石層）は、鉄、コバルト、ニッケル等の強磁性材料から構成することができる。位置制御手段を電磁石から構成する場合、鉄、コバルト、ニッケル等の強磁性材料から成る芯部（コア部）、及びこの芯部を取り囲むコイルから電磁石を構成することができる。トランジスタ素子としては、如何なる形式のトランジスタ素子をも用いることができるが、例えばＭＯＳ型トランジスタ素子やバイポーラトランジスタ素子を挙げることができる。

【００１４】

【作用】本発明のデジタルマイクロミラーデバイスにおいては、マイクロミラー部は位置制御手段に対して移動自在に取り付けられており、従来の技術のようにマイクロミラー部が堅固に固定されていない。従って、マイクロミラー部にねじれ等の力が加わらず、高い信頼性をデジタルマイクロミラーデバイスに付与することができる。また、マイクロミラー部の駆動を、従来技術のようにクーロン力で駆動するのではなく、磁力で駆動すれば、駆動力が向上し且つ安定し、マイクロミラーデバイスの確実な動作を保証することができる。

【００１５】

【実施例】以下、図面を参照して、実施例に基づき本発明を説明する。尚、実施例１は、マイクロミラー部の下部には一体となった支柱が設けられており、この支柱が

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永久磁石から成り、支柱は位置制御手段の近傍に配置されている第１の態様に関する。また、実施例２は、マイクロミラー部の下部には一体となった支柱が設けられており、この支柱の少なくとも底部に永久磁石層が設けられており、支柱は位置制御手段の近傍に配置されている第２の態様に関する。更に、実施例３は、マイクロミラー部の下部には一体となった支柱が設けられており、マイクロミラーの底面及び支柱の外面に永久磁石層が備えられており、この支柱は位置制御手段の近傍に配置されている第３の態様に関する。

【００１６】（実施例１）本発明のデジタルマイクロミラーデバイスはマイクロミラー素子を複数配列して成る。マイクロミラー素子の各々は、図１に模式的な一部断面図を示すように、（イ）１つのマイクロミラー部４３，４２と、（ロ）この１つのマイクロミラー部４３，４２に対応して設けられた、マイクロミラー部の位置を制御するための１つの位置制御手段３０，３５，３２と、（ハ）この位置制御手段を制御するための１つのトランジスタ素子１５，１６、から成る。そして、マイクロミラー部４３，４２は位置制御手段３０，３５，３２に対して移動自在に取り付けられている。

【００１７】マイクロミラー部４３，４２には永久磁石４２が備えられている。一方、位置制御手段３０，３５，３２は一種の電磁石から成り、そしてその一端はトランジスタ素子１５，１６に接続されている。トランジスタ素子１５，１６は、ＭＯＳ型トランジスタ素子である。そして、トランジスタ素子１５，１６の制御により位置制御手段３０，３５，３２に発生する電磁力によってマイクロミラー部４３，４２の位置を制御する。具体的には、トランジスタ素子１５，１６のオンオフ制御により位置制御手段３０，３５に電流を流し、これにより位置制御手段３０，３５，３２で発生する電磁力によってマイクロミラー部４３，４２に備えられた永久磁石４２との間に生じる引力・斥力を利用して、マイクロミラー部４３，４２の位置を制御する。

【００１８】実施例１においては、マイクロミラー部４３，４２は、マイクロミラー本体４３と、マイクロミラー本体４３の下部に一体となって設けられた支柱４２から構成されており、この支柱４２は永久磁石から成る。そして、支柱４２は、位置制御手段３０，３５，３２の近傍に移動自在に配置されている。また、マイクロミラー部の動きを制限するためのガイド部４４がマイクロミラー本体４３の近傍に設けられている。

【００１９】実施例１においては、位置制御手段に対するマイクロミラー部の上下動によって、マイクロミラー部の位置制御が行われる。図１には、マイクロミラー部が位置制御手段から最も離れた位置にある状態を図示した。

【００２０】あるいは又、本発明のデジタルマイクロミラーデバイスは、図１に模式的な一部断面図に示すように（イ）半導体基板１０に形成されたトランジスタ素子１５，１６と、（ロ）トランジスタ素子１５，１６上に形成された絶縁層２０の上に設けられ、トランジスタ素子に電気的に接続された位置制御手段３０，３５，３２と、（ハ）マイクロミラー本体４３と支柱４２とから成り、位置制御手段の上に形成されたガイド層４０の上にマイクロミラー本体４３が配置され、ガイド層４０に設けられた穴部４０Ａに支柱４２が移動自在に収納されており、位置制御手段の動作によって支柱４２の位置が制御されるところのマイクロミラー部４３，４２、から構成されたマイクロミラー素子を複数配列して成る。

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【００２１】図２に、本発明のマイクロミラー素子の動作原理を示す。図２の（Ａ）に示すように、トランジスタ素子１５，１６がオフの状態にあっては、トランジスタ素子に接続された位置制御手段には電流が流れていない。従って、位置制御手段３０，３２，３５には電磁力が発生せず、マイクロミラー部に備えられた永久磁石４２とこの位置制御手段との間に働く引力によって、マイクロミラー部と位置制御手段とは一定の距離に置かれる。その結果、マイクロミラー部に入射した光は所定の方向に射出される。マイクロミラー部から射出された光は、デジタルマイクロミラーデバイスとスクリーンとの間に設けられた開口部を有する遮蔽板によって遮られ、スクリーンに到達しない。

【００２２】図２の（Ｂ）に示すように、トランジスタ素子をオン状態にすると、トランジスタ素子１５，１６に接続された位置制御手段には電流が流れ、位置制御手段３０，３２，３５に電磁力が発生する。マイクロミラー部に備えられた永久磁石４２とこの位置制御手段との間に働く斥力によって、マイクロミラー部は位置制御手段から離れる方向に移動する。その結果、マイクロミラー部に入射した光の射出方向は、位置制御手段の動作前の射出方向から変化する。マイクロミラー部から射出された光は、デジタルマイクロミラーデバイスとスクリーンとの間に設けられた遮蔽板の開口部を通過し、スクリーンに到達する。尚、トランジスタ素子のオンオフ状態における光のスクリーンへの到達状態を上記の説明と逆にしてもよい。

【００２３】スクリーン上に映像を投影する場合には、光源から射出された光を例えば３６００ｒｐｍの回転速度で回転する円盤型のＲＧＢのカラーフィルタを通し、本発明のデジタルマイクロミラーデバイスに入射させる。円盤型のカラーフィルタを回転させることによって、白色の光をＲＧＢの３色に変換する。このＲＧＢの光がデジタルマイクロミラーデバイスのマイクロミラー部で反射される。そして、トランジスタ素子がオン状態（構成によってはオフ状態）にあるマイクロミラー素子のマイクロミラー部で反射された光のみが、投影レンズを介してスクリーンに到達する。ＲＧＢの表示時間を時分割することによって、階調を制御することが可能であ

る。

【００２４】以下、図１に示した実施例１のデジタルマイクロミラーデバイスの作製方法を、半導体基板等の模式的な一部断面図である図３～図６を参照して説明する。

【００２５】［工程－１００］先ず、シリコン半導体基板１０に従来の方法に基づきＭＯＳ型トランジスタ素子を作製する（図３の（Ａ）参照）。そのために、先ず、従来の方法でシリコン半導体基板１０にSiO_2から成る素子分離領域１１を形成した後、シリコン半導体基板１０の表面を酸化してゲート酸化膜１２を形成する。次いで、例えばＣＶＤ法で全面にポリシリコン層を堆積させた後、フォトリソグラフィ技術及びドライエッチング技術によって、ポリシリコン層を選択的に除去し、ゲート電極１３を形成する。その後、従来の方法でＬＤＤ構造を形成するための不純物イオン注入を行い、次いで、ゲート電極の側壁にSiO_2から成るゲートサイドウオール１４を設ける。こうして、ゲート酸化膜１２、ポリシリコンから成るゲート電極１３及びゲートサイドウオール１４から構成されたゲート電極部１５を形成することができる。その後、不純物イオン注入を行い、シリコン半導体基板１０にソース・ドレイン領域１６を形成する。これらの各工程は公知の方法に基づき実行することができる。

【００２６】［工程－１１０］その後、ＭＯＳ型トランジスタ素子に電気的に接続された位置制御手段をＭＯＳ型トランジスタ素子の上方に絶縁層を介して形成する。

【００２７】［工程－１１０Ａ］そのために、先ず、全面に例えばSiO_2から成り厚さ０．５μｍの絶縁層２０をＣＶＤ法にて形成する。ＣＶＤ法の条件を以下に例示する。

使用ガス：　ＴＥＯＳ＝５０sccm
基板温度：　７２０°Ｃ
圧力　　：　４０Ｐａ

【００２８】尚、絶縁層２０を構成する材料はSiO_2に限定されず、他の公知の絶縁材料、例えばＢＰＳＧ、ＰＳＧ、ＢＳＧ、ＡｓＳＧ、ＰｂＳＧ、ＳｂＳＧ、ＳＯＧ、ＳｉＯＮ、ＳｉＮあるいはこれらの絶縁膜を積層したものを挙げることができる。

【００２９】［工程－１１０Ｂ］次に、ソース・ドレイン領域１６の上方の絶縁層２０にフォトリソグラフィ技術及びドライエッチング技術を用いて開口部２１を形成する。ドライエッチングの条件を、例えば以下のとおりとすることができる。

使用ガス　：　C_4F_8＝５０sccm
ＲＦパワー：　１２００Ｗ
圧力　　：　２Ｐａ

【００３０】［工程－１１０Ｃ］その後、開口部２１内を金属配線材料で埋め込む。そのために、先ず、スパッタ法を用いて、開口部２１内を含む絶縁層２０上に、下から例えばＴｉ及びＴｉＮ層２２を堆積させる。このＴｉＮ／Ｔｉ層は所謂バリアメタル層及びコンタクト抵抗低減層としての機能を果たす。次いで、例えば所謂ブランケットタングステンＣＶＤ法を用いて、開口部２１内を含むＴｉＮ／Ｔｉ層２２上にタングステン（Ｗ）層２３を堆積させる。その後、絶縁層２０上のタングステン層及びＴｉＮ／Ｔｉ層を除去し、開口部２１内のみを、ＴｉＮ／Ｔｉ層２２及びタングステン層２３で埋め込む（図３の（Ｂ）参照）。Ｔｉ層及びＴｉＮ層の成膜条件、ブランケットタングステンＣＶＤ法によるタングステン層の成膜条件、並びにタングステン層とＴｉＮ／Ｔｉ層のエッチバック条件を、以下に例示する。

Ｔｉ層の成膜条件
使用ガス　：　Ａｒ＝１００sccm
パワー　　：　４ｋＷ
圧力　　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ
膜厚　　：　３０ｎｍ

ＴｉＮ層の成膜条件
使用ガス　：　Ar/N_2＝４０／７０sccm
パワー　　：　５ｋＷ
圧力　　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ
膜厚　　：　７０ｎｍ

ブランケットタングステンＣＶＤ法によるＷ層の成膜条件
使用ガス　：　WF_6/H_2＝９５／５５０sccm
成膜温度　：　４５０°Ｃ
圧力　　：　１．１×10^4Ｐａ
膜厚　　：　０．４μｍ

エッチバックの条件
使用ガス　　：　SF_6＝５０sccm
マイクロ波パワー　：　８５０Ｗ
ＲＦパワー　　：　１５０Ｗ
圧力　　：　１．３３Ｐａ

【００３１】［工程－１１０Ｄ］その後、絶縁層２０の上に位置制御手段を形成する。そのために、先ず、全面に例えばアルミニウムあるいはアルミニウム系合金（以下、総称してＡｌ系合金と呼ぶ場合もある）から成る第１の導電層３０を、例えばスパッタ法で形成する。第１の導電層３０の形成条件を以下に例示する。

使用ガス　：　Ａｒ＝４０sccm
パワー　　：　２２．５ｋＷ
成膜温度　：　１５０°Ｃ
圧力　　：　０．４７Ｐａ
膜厚　　：　０．３μｍ、

Ａｌ系合金として、純アルミニウム、Ａｌ－Ｓｉ、Ａｌ－Ｃｕ、Ａｌ－Ｓｉ－Ｃｕ、Ａｌ－Ｇｅ、Ａｌ－Ｓｉ－Ｇｅ等の種々のアルミニウム合金を例示することができる。

【００３２】［工程－１１０Ｅ］その後、フォトリソグラフィ技術及びドライエッチング技術を用いて、第１の導電層３０を所望の平面形状にパターニングする。ドライエッチング条件を例えば以下のとおりとすることができる。

使用ガス　：　BCl_3／Cl_2＝６０／９０sccm
マイクロ波パワー　：　１０００Ｗ
ＲＦパワー　：　５０Ｗ
圧力　：　０．０１６Ｐａ

【００３３】尚、ブランケットタングステンＣＶＤ法によりタングステン層２３で開口部２１を埋め込む工程を省略し、ＴｉＮ層／Ｔｉ層２２の上にＡｌ系合金層をスパッタ法にて堆積させた後、絶縁層２０の上のＡｌ系合金層とＴｉＮ／Ｔｉ層２２を選択的に除去することによって、開口部２１内をＡｌ系合金で埋め込み、併せてパターニングされた第１の導電層３０を得ることもできる。

【００３４】第１の導電層３０を構成するＡｌ系合金の代わりに、Ｗ、Ｃｕ、Ａｇ等の金属配線材料を用いることができる。また、これらの金属配線材料の形成方法はスパッタ法に限定されず、例えばＣＶＤ法を用いることもできる。

【００３５】［工程－１１０Ｆ］次に、バイアスＥＣＲ　ＣＶＤ法にて全面に例えばＳｉＮから成る平坦な第１の層間絶縁層３１を全面に形成する（図３の（Ｃ）参照）。第１の層間絶縁層３１の形成条件を以下に例示する。

使用ガス　：　SiH_4／N_2O＝２１／３５sccm
マイクロ波パワー　：　１０００Ｗ
ＲＦパワー　：　３００Ｗ
成膜温度　：　４５０°Ｃ
圧力　：　０．０１Ｐａ

【００３６】［工程－１１０Ｇ］その後、第１の層間絶縁層３１の上にスパッタ法で例えば鉄から成る芯（コア）層３２を形成する。芯層３２の成膜条件を以下に例示する。

使用ガス　：　Ａｒ＝１００sccm
パワー　：　４ｋＷ
圧力　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ
膜厚　：　７０ｎｍ

【００３７】尚、鉄の代わりに、Ｃｏ、Ｎｉ等、あるいはこれらの材料の合金や酸化物等の強磁性材料から芯層３２を構成することもできる。

【００３８】［工程－１１０Ｈ］次に、フォトリソグラフィ技術及びドライエッチング技術を用いて、芯層３２を所望の平面形状（例えば、矩形）にパターニングする（図４の（Ａ）参照）。ドライエッチング条件を、例えば以下のとおりとすることができる。

使用ガス　：　BCl_3／Cl_2＝６０／９０sccm
マイクロ波パワー　：　１０００Ｗ
ＲＦパワー　：　５０Ｗ
圧力　：　０．０１６Ｐａ
基板温度　：　３５０°Ｃ

【００３９】［工程－１１０Ｉ］その後、バイアスＥＣＲ　ＣＶＤ法にて全面に例えばＳｉＮから成る平坦な第２の層間絶縁層３３を全面に形成する。第２の層間絶縁層３３の形成条件を、第１の層間絶縁層３１の形成条件と同様とすることができる。次いで、フォトリソグラフィ技術及びドライエッチング技術を用いて、第２の層間絶縁層３３に開口部３４を形成する。ドライエッチング条件を以下に例示する。

使用ガス　：　C_4F_8＝５０sccm
ＲＦパワー　：　１２００Ｗ
圧力　：　２Ｐａ

【００４０】尚、第１の層間絶縁層３１あるいは第２の層間絶縁層３３を構成する材料はＳｉＮに限定されず、他の公知の絶縁材料、例えばSiO_2、ＢＰＳＧ、ＰＳＧ、ＢＳＧ、ＡｓＳＧ、ＰｂＳＧ、ＳｂＳＧ、ＳＯＧ、ＳｉＯＮ、あるいはこれらの絶縁膜を積層したものを挙げることができる。

【００４１】こうして、図４の（Ｂ）に示す構造を得ることができる。尚、図４の（Ｂ）において、芯層３２にも開口部が形成されているかのように図示されているが、実際には、芯層３２には開口部は形成されていない。開口部３４は、第２の層間絶縁層３３にのみ形成されている。また、図４の（Ｂ）においては、パターニングされた第１の導電層３０の領域の各々の右側の部分に開口部３４が形成された状態を示したが、実際には、パターニングされた第１の導電層３０の各々の左側の部分にも開口部（図示せず）が形成されている。

【００４２】［工程－１１０Ｊ］次に、スパッタ法にて開口部３４内を含む第２の層間絶縁層３３上に例えばＴｉＮ層（図示せず）を成膜し、更に、その上に例えばブランケットタングステンＣＶＤ法でタングステンから成る第２の導電層３５を形成する。ＴｉＮ層の成膜条件は、［工程－１１Ｃ］のＴｉＮ層の成膜条件と同様とすることができる。第２の導電層の成膜条件

使用ガス　：　WF_6／H_2＝９５／５５０sccm
成膜温度　：　４５０°Ｃ
圧力　：　1.1×10^4Ｐａ
膜厚　：　０．３μｍ

【００４３】［工程－１１０Ｋ］その後、フォトリソグラフィ技術及びドライエッチング技術を用いて、第２の導電層３５及びＴｉＮ層のパターニングを、［工程－１１０Ｃ］のエッチバック条件と同様の条件で行なう。

【００４４】尚、ブランケットタングステンＣＶＤ法に

よる第２の導電層３５の形成の代わりに、スパッタ法やＣＶＤ法で他の金属配線材料を開口部３４内を含む第２の層間絶縁層３３上に成膜することで第２の導電層３５を形成することもできる。

【００４５】［工程－１１０Ｌ］更に、例えばＢＰＳＧから成る第３の層間絶縁層３６を全面に堆積させた後、加熱による第３の層間絶縁層３６の平坦化処理を行う。こうして、図５の（Ａ）に示す構造を得ることができる。第３の層間絶縁層３６の成膜条件を以下に例示する。

使用ガス　：　SiH_4／PH_3／B_2H_6／O_2／N_2＝８０／７／７／１０００／３２０００sccm
成膜温度　：　４００°Ｃ
圧力　　：　１．０×10^5Ｐａ
膜厚　　：　０．１５μｍ

【００４６】尚、第３の層間絶縁層３６を構成する材料はＢＰＳＧに限定されず、後に形成する犠牲層をエッチングする際に同時にエッチングされない材料であれば、如何なる公知の絶縁材料をも用いることができる。

【００４７】こうして、例えば鉄からなり電磁石の芯部（コア部）に相当する芯層３２、並びに、コイルに相当する第１の導電層３０と第２の導電層３５（これらの層３０，３５は開口部３４及び図示していない開口部を介して順次電気的に接続されている）から構成された一種の電磁石である位置制御手段が完成する。コイルの一端（パターニングされた第１の導電層３０の一部分）は、開口部２１内に埋め込まれたＴｉＮ／Ｔｉ層２２及びタングステン層２３を介してＭＯＳ型トランジスタ素子のソース・ドレイン領域１６と電気的に接続されている。一方、コイルの他端である第２の導電層３５の端部（あるいは、場合によっては第１の導電層３０の他の端部）は、例えば接地されている（図示せず）。これによって、ＭＯＳ型トランジスタ素子がオン状態になると、第１の導電層３０と第２の導電層３５から構成されたコイルに電流が流れ、磁界が発生する。

【００４８】［工程－１２０］次に、マイクロミラー部４３，４２を位置制御手段３０，３５，３２の上方に形成する。

【００４９】［工程－１２０Ａ］そのために、先ず、全面に例えばポリシリコンから成るガイド層４０を形成する。ガイド層４０のＣＶＤ形成条件を以下に例示する。

使用ガス　：　SiH_4／Ｈｅ＝５００／５０sccm
圧力　　：　８０Ｐａ
成膜温度　：　４００°Ｃ
膜厚　　：　０．８μｍ

【００５０】尚、ガイド層を構成する材料として、ポリシリコンの代わりに、後に形成する犠牲層をエッチングする際に同時にエッチングされない材料であって光を反射しない材料であれば、如何なる公知の材料をも用いることができる。

【００５１】［工程－１２０Ｂ］その後、フォトリソグラフィ技術及びドライエッチング技術によってポリシリコンから成るガイド層４０に穴部４０Ａを形成する。尚、この穴部４０Ａに、後に形成する支柱が収納される。ドライエッチングの条件を、例えば［工程－１１０Ｉ］と同様とすることができる。

【００５２】［工程－１２０Ｃ］次いで、穴部４０Ａを含むガイド層４０の全面に例えばSiO_2から成る犠牲層（分離層）４１を、例えば以下に例示する条件のＣＶＤ法にて形成する（図５の（Ｂ）参照）。

使用ガス　：　SiH_4／O_2／N_2＝８０／１０００／３２０００sccm
成膜温度　：　４００°Ｃ
圧力　　：　１．０×10^5Ｐａ
膜厚　　：　５０ｎｍ

【００５３】［工程－１２０Ｄ］その後、例えば以下の条件のスパッタ法にて、全面に鉄層を堆積させる。

使用ガス　：　Ａｒ＝１００sccm
パワー　　：　４ｋＷ
圧力　　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ
膜厚　　：　１．０μｍ

【００５４】［工程－１２０Ｅ］そして、この状態で、別に準備した磁石を鉄層に近づけ、鉄層を磁化させる。その後、フォトリソグラフィ技術及びドライエッチング技術を用いて、鉄層をパターニングし、穴部４０Ａの中に鉄層を残す。ドライエッチング条件は、［工程－１１０Ｈ］と同様とすることができる。こうして、図６の（Ａ）に示す構造を得ることができる。穴部４０Ａの中に残された鉄層が支柱４２に相当する。また、鉄層から成る支柱４２は永久磁石化される。

【００５５】［工程－１２０Ｆ］次に、犠牲層４１上及び支柱４２上に例えばＡｌ系合金層をスパッタ法で形成する。Ａｌ系合金層の形成条件を以下に例示する。

使用ガス　：　Ａｒ＝４０sccm
パワー　　：　２２．５ｋＷ
成膜温度　：　５００°Ｃ
圧力　　：　０．４７Ｐａ
膜厚　　：　０．３μｍ

【００５６】［工程－１２０Ｇ］その後、フォトリソグラフィ技術及びドライエッチング技術を用いて、Ａｌ系合金層をパターニングし、Ａｌ系合金層から成るマイクロミラー本体４３を形成する。ドライエッチングの条件は［工程－１１０Ｅ］と同様とすることができる。こうして、図６の（Ｂ）に示す構造を得ることができる。

【００５７】［工程－１２０Ｈ］次に、マイクロミラー本体４３近傍の犠牲層４１に開口部を形成した後、全面に例えばポリシリコン層を堆積させる。そして、ポリシリコン層を選択的に除去し、ガイド部を構成する垂直壁４４Ａをポリシリコン層から形成する。次に、例えばＳ

iO_2から成る犠牲層４５を全面に堆積させる（図７の（Ａ）参照）。その後、全面に再びポリシリコン層を堆積させ、かかるポリシリコン層を選択的に除去して、ガイド部を構成する水平方向の突起部４４Ｂを形成する（図７の（Ｂ）参照）。

【００５８】［工程－１２０Ｉ］最後に、ドライエッチング法にて、SiO_2から成る犠牲層４５，４１を除去する。ドライエッチングの条件を以下に例示する。

使用ガス　：　CF_4＝１００sccm
ＲＦパワー：　５０Ｗ
圧力　　：　６Ｐａ

【００５９】こうして、図１に示した構造のマイクロミラー素子を作製することができる。

【００６０】（実施例２）実施例２は実施例１の変形であり、マイクロミラー部の構造が実施例１と相違する。即ち、実施例２は、マイクロミラー部の下部には一体となった支柱が設けられており、このポリシリコンから成る支柱の底部（実施例２においては支柱の外面の全面）に永久磁石層５０が設けられており、支柱は位置制御手段の近傍に移動自在に配置されている第２の態様に関する。また、マイクロミラー部におけるマイクロミラー本体は、Ａｌ系合金層５２及びタングステン層５３の２層構造であり、タングステン層５３によって光が反射される。

【００６１】実施例２のデジタルマイクロミラーデバイスの作製においては、位置制御手段の形成まで、即ち、第３の層間絶縁層３６の形成工程までは、実施例１と同様とすることができる。それ故、マイクロミラー部の形成方法のみを、以下、図８及び図９を参照して説明する。

【００６２】［工程－２００Ａ］第３の層間絶縁層３６の上に、実施例１の［工程－１２０Ａ］～［工程－１２０Ｃ］と同様に、例えばポリシリコンから成るガイド層４０を形成した後、ガイド層４０に穴部４０Ａを形成する。次いで、穴部４０Ａを含むガイド層４０の全面にSiO_2から成る犠牲層（分離層）４１をＣＶＤ法にて形成する（図８の（Ａ）参照）。

【００６３】［工程－２００Ｂ］その後、例えば以下の条件のスパッタ法にて、全面に鉄層を堆積させる。鉄層の厚さは、穴部４０Ａが鉄層で埋め込まれない厚さとする。

使用ガス　：　Ａｒ＝１００sccm
パワー　　：　４ｋＷ
圧力　　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ
膜厚　　：　７０ｎｍ

【００６４】［工程－２００Ｃ］そして、この状態で、別に準備した磁石を鉄層に近づけ、鉄層を磁化し、鉄層を永久磁石化する。

【００６５】［工程－２００Ｄ］その後、フォトリソグラフィ技術及びドライエッチング技術を用いて、鉄層をパターニングし、穴部４０Ａの中に鉄層を残す。ドライエッチング条件は、実施例１の［工程－１１０Ｈ］と同様とすることができる。こうして、永久磁石層５０を穴部４０Ａの底部及び側壁部に形成することができる。

【００６６】［工程－２００Ｅ］次いで、全面にポリシリコン層５１を形成する。ポリシリコン層５１のＣＶＤ形成条件を、実施例１の［工程－１２０Ａ］と同様とすることができる。

【００６７】［工程－２００Ｆ］その後、ポリシリコン層５１を全面エッチバックし、穴部４０Ａの内に形成された永久磁石層５０の凹部内にのみポリシリコン層５１を残す。こうして、図８の（Ｂ）に示す構造を得ることができる。穴部４０Ａの中に残された永久磁石層５０及びポリシリコン層５１が支柱に相当する。言い換えれば、支柱の少なくとも底部（実施例２においては支柱の外面の全て）に永久磁石層５０が設けられる。ポリシリコン層のエッチバック条件を以下に例示する。

使用ガス　　：　$C_2Cl_3F_3$／SF_6＝６５／５sccm
マイクロ波パワー：　８５０Ｗ
ＲＦパワー　　：　１５０Ｗ
圧力　　：　１．３３Ｐａ

【００６８】［工程－２００Ｇ］その後、実施例１の［工程－１２０Ｆ］と同様の条件で、Ａｌ系合金層５２を全面に成膜する。次に、以下に例示するＣＶＤ法でＡｌ系合金層５２の上にタングステン層５３を成膜する。

使用ガス　：　WF_6／H_2＝９５／５５０sccm
成膜温度　：　４５０°Ｃ
圧力　　：　1.1×10^4Ｐａ
膜厚　　：　３０ｎｍ

【００６９】［工程－２００Ｈ］次に、フォトリソグラフィ技術及びドライエッチング技術を用いて、タングステン層５３及びＡｌ系合金層５２を所望のパターンにエッチングする（図８の（Ｃ）参照）。エッチング条件を以下に例示する。

使用ガス　　：　BCl_3／Cl_2＝６０／９０sccm
マイクロ波パワー　：　１０００Ｗ
ＲＦパワー　　：　５０Ｗ
圧力　　：　０．０１６Ｐａ

【００７０】［工程－２００Ｉ］その後、再び全面に厚さ１００ｎｍのタングステン層５４を［工程－２００Ｇ］と同様の条件のＣＶＤ法にて堆積させる。そして、タングステン層５４を、実施例１の［工程－１１０Ｃ］と同様の条件でエッチバックする。こうして、図９の（Ａ）に示す構造を得ることができる。Ａｌ系合金層５２は、頂面及び側面がタングステン層５３，５４で被覆されており、マイクロミラー本体に高い信頼性を付与することができる。

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【００７１】［工程－２００Ｊ］その後、実施例１の［工程－１２０Ｈ］と同様の方法でマイクロミラー本体４３の近傍にガイド部（図示せず）を形成した後、希釈フッ酸溶液（ＨＦ：H_2O＝５：１００）に例えば５分間浸漬することで犠牲層４１等を除去する。こうして、図９の（Ｂ）に示す構造のマイクロミラー部を作製することができる。尚、最後にＡｌ系合金層５２上及び側壁のタングステン層５３，５４を以下に例示するプラズマエッチング法にて除去してもよい。

使用ガス　：　CF_4＝１００sccm
ＲＦパワー：　５０Ｗ
圧力　　：　６Ｐａ

【００７２】（実施例３）実施例３も実施例１の変形であり、マイクロミラー部の構造が実施例１と相違する。即ち、実施例３は、マイクロミラー部の下部には一体となった支柱が設けられており、マイクロミラー部の底面（より具体的には、マイクロミラー本体の底面）及び支柱の外面に永久磁石層が備えられており、この支柱は位置制御手段の近傍に移動自在に配置されている第３の態様に関する。また、マイクロミラー部におけるマイクロミラー本体は、ポリシリコン層６２及びＡｌ系合金層６３の２層構造であり、Ａｌ系合金層６３によって光が反射される。実施例１においては犠牲層をSiO_2から形成したが、実施例３においては有機レジスト材料から犠牲層を形成した。また、永久磁石層はコバルト（Ｃｏ）から成る。

【００７３】実施例３のデジタルマイクロミラーデバイスの作製においては、位置制御手段の形成まで、即ち、第３の層間絶縁層３６の形成工程までは、実施例１と同様とすることができる。それ故、マイクロミラー部の形成方法のみを、以下、図１０及び図１１を参照して説明する。

【００７４】［工程－３００Ａ］第３の層間絶縁層３６の上に、実施例１の［工程－１２０Ａ］～［工程－１２０Ｂ］と同様に、ポリシリコンから成るガイド層４０を形成した後、ガイド層に穴部４０Ａを形成する。次いで、穴部４０Ａを含むガイド層４０の全面に有機レジスト材料から成る犠牲層（分離層）６０をスピンコートにて形成する（図１０の（Ａ）参照）。犠牲層６０の形成条件を以下に例示する。

使用レジスト材料　：　ＯＦＰＲ　３０ｃｐ
塗布コーター回転数　：　２０００rpm
塗布後のベーキング　：　１００°Ｃ

【００７５】［工程－３００Ｂ］その後、例えば以下の条件のスパッタ法にて、穴部４０Ａの中を含む犠牲層６０の上全面にＣｏ層６１を堆積させる。

使用ガス　：　Ａｒ＝１００sccm
パワー　　：　４ｋＷ
圧力　　：　０．４７Ｐａ
成膜温度　：　１５０°Ｃ

16

膜厚　　：　０．３μｍ

【００７６】［工程－３００Ｃ］そして、この状態で、別に準備した磁石をＣｏ層６１に近づけ、Ｃｏ層６１を磁化し、Ｃｏ層６１を永久磁石化する。即ち、Ｃｏ層６１が永久磁石層となる。

【００７７】［工程－３００Ｄ］その後、全面に厚さ０．５μｍのポリシリコン層６２を形成する。ポリシリコン層６２のＣＶＤ形成条件は、例えば実施例１の［工程－１２０Ａ］と略同様とすることができる。尚、ポリシリコン層６２は、穴部４０Ａ内に堆積したＣｏ層６１の凹部内にも堆積し、かかるポリシリコン層が支柱に相当する。

【００７８】［工程－３００Ｅ］その後、実施例１の［工程－１２０Ｆ］と同様の条件で、Ａｌ系合金層６３を全面に成膜する。こうして、図１０の（Ｂ）に示す構造を得ることができる。マイクロミラー部６２，６３の底面及び支柱の外面にＣｏ層６１から成る永久磁石層が備えられる。

【００７９】［工程－３００Ｆ］次に、フォトリソグラフィ技術及びドライエッチング技術を用いて、Ａｌ系合金層６３、ポリシリコン層６２及びＣｏ層６１を、以下に例示する条件でパターニングする。

Ａｌ系合金層のパターニング
使用ガス　　：　BCl_3／Cl_2＝６０／９０sccm
マイクロ波パワー：　１０００Ｗ
ＲＦパワー　　：　５０Ｗ
圧力　　：　０．０１６Ｐａ
ポリシリコン層のパターニング
使用ガス　：　C_4F_8／Ａｒ＝５０／１０sccm
ＲＦパワー　：　１２００Ｗ
圧力　　：　２Ｐａ

尚、Ｃｏ層６１は、ポリシリコン層６２のドライエッチング後のオーバーエッチングでパターニングすることができる。

【００８０】［工程－３００Ｇ］その後、例えば以下の条件の酸素プラズマアッシャー処理を行い、有機レジスト材料から成る犠牲層６０を除去する。

使用ガス　　：　O_2＝２０sccm
ＲＦプラズマ　：　２００Ｖ
圧力　　：　１ａｔｍ

酸素プラズマアッシャー処理の後、発煙硝酸で犠牲層６０を完全に除去する。

【００８１】以上、本発明のデジタルマイクロミラーデバイスを好ましい実施例に基づき説明したが、本発明はこれらの実施例に限定されるものではない。各実施例にて説明した各種成膜条件は例示であり、適宜変更することができる。成膜方法もスパッタ法とＣＶＤ法とを適宜置き換えることが可能である。

【００８２】実施例においては、マイクロミラー部の位置制御は、専ら位置制御手段に対する上下動によった

が、マイクロミラー部を回動させる（角度変位させる）ことで位置制御手段に対するマイクロミラー部の位置制御（角度制御）を行ってもよい。この場合には、例えば、ガイド部４４を構成する水平方向の突起部４４Ｂとガイド層４０との間の隙間を、図１のマイクロミラー部の左側と右側とで相違させればよいし、マイクロミラー部の１つの辺の近傍にガイド部４４を設けてもよい。。あるいは又、支柱の側壁に１つの突起部又はピン部を設け、穴部４０Ａの側壁にかかる突起部又はピン部と緩やかに係合する孔を形成すればよい。位置制御手段の構造は例示であり、適宜構造を変更することができる。

【００８３】

【発明の効果】従来のデジタルマイクロミラーデバイスにおいては、鏡の固定部分が捻れることによって鏡が回転させられていたために、固定部分が損傷し易く、耐久性が悪かった。然るに、本発明のデジタルマイクロミラーデバイスにおいては、支柱とマイクロミラー本体が一体となっており、しかも、マイクロミラー部は位置制御手段に固定されておらず、移動自在に配置されている。従って、マイクロミラー部を駆動しても、マイクロミラー部に不所望の力が加わらず、従来のマイクロミラーデバイスより耐久性が格段に向上する。また、トランジスタ素子１つでマイクロミラー部を駆動することができるため、マイクロミラー部の集積度が向上する。

【００８４】しかも、金属材料からマイクロミラー部の光反射面を構成しているので、光の反射率はほぼ１００％が得られ、デジタルマイクロミラーデバイスから投影される映像の輝度は極めて高く、且つ投影装置も軽量化が図られる。これに対して、従来の液晶デバイスを用いた表示装置は光の透過率が数％と非常に悪いため、輝度が低い。特に、ＨＤ用モニターの高画質、軽量化、低価格化を実現することが可能になる。

【００８５】更には、従来のクーロン力を用いたデジタルマイクロミラーデバイスよりも、本発明のデジタルマイクロミラーデバイスの駆動力は格段に向上するので、安定した映像の投影を確保することができる。

【図面の簡単な説明】

【図１】実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の模式的な断面図である。

【図２】本発明のデジタルマイクロミラーデバイスの動作原理を説明する概要図である。

【図３】実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図４】図３に引き続き、実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図５】図４に引き続き、実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図６】図５に引き続き、実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図７】図６に引き続き、実施例１のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図８】実施例２のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図９】図８に引き続き、実施例２のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図１０】実施例３のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図１１】図１０に引き続き、実施例２のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の作製方法を説明するための模式的な断面図である。

【図１２】従来のデジタルマイクロミラーデバイスの動作原理を説明する概要図、及び、従来のデジタルマイクロミラーデバイスにおけるマイクロミラー素子の模式的な断面図である。

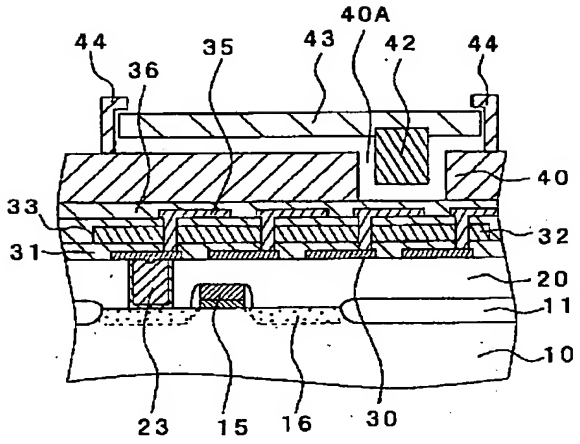
【符号の説明】

１０　シリコン半導体基板
１１　素子分離領域
１２　ゲート酸化膜
１３　ゲート電極
１４　ゲートサイドウオール
１５　ゲート電極部
１６　ソース・ドレイン領域
２０　絶縁層
２１　開口部
２２　ＴｉＮ／Ｔｉ層
２３　タングステン層
３０，３５　導電層
３１，３３，３６　層間絶縁層
３２　芯（コア）層
３４　開口部
４０　ガイド層
４０Ａ　穴部
４１，６０　犠牲層（分離層）
４２　支柱
４３　マイクロミラー本体
４４　ガイド部
５０　永久磁石層
５１　ポリシリコン層
５２　Ａｌ系合金層
５３，５４　タングステン層
６１　Ｃｏ層
６２　ポリシリコン層

６３　Ａｌ系合金層

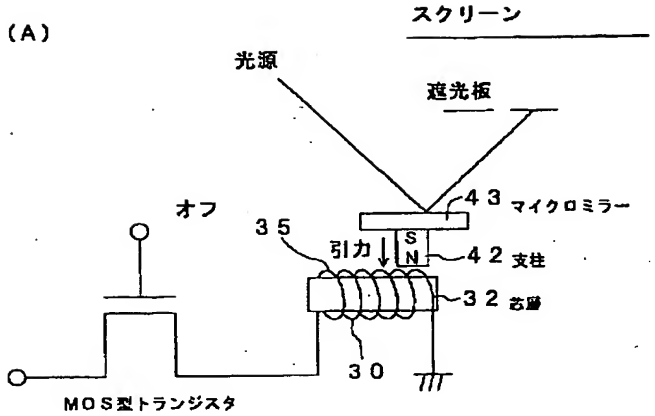
【図１】

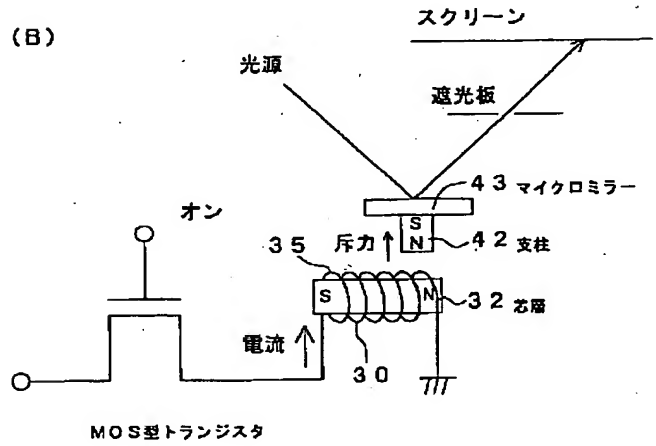
（実施例１）



【図２】

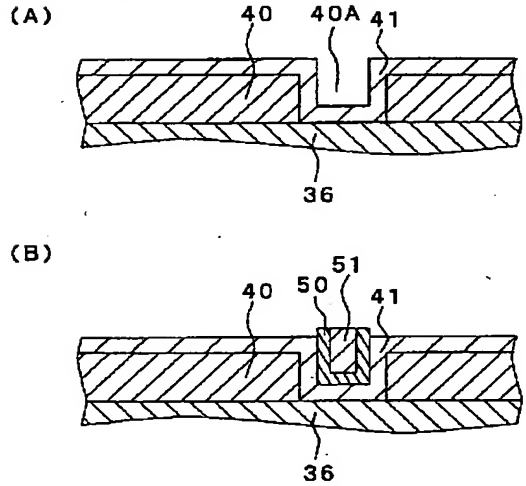
（原理図）





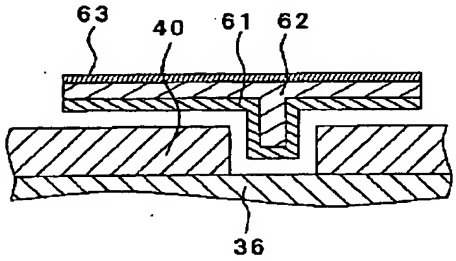
【図８】

（実施例２）　その１



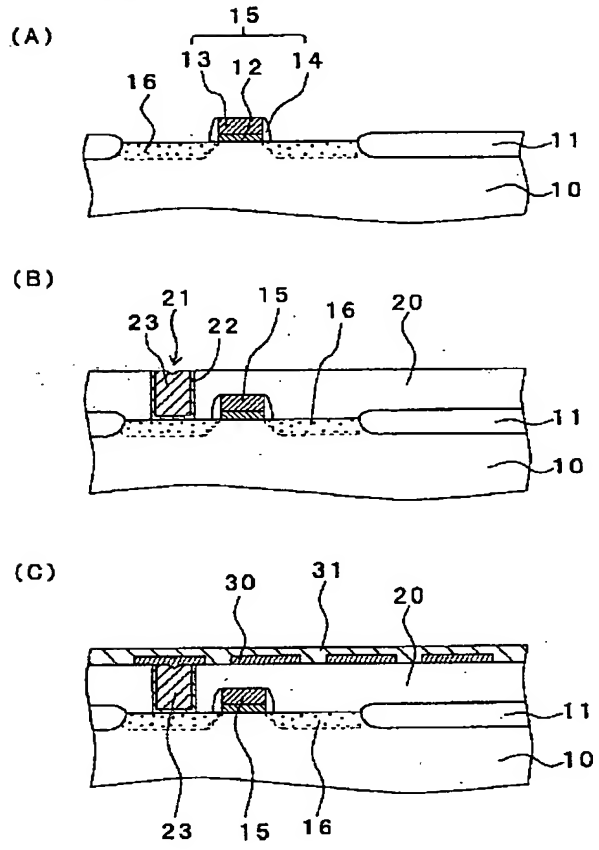
【図１１】

（実施例３）　その２



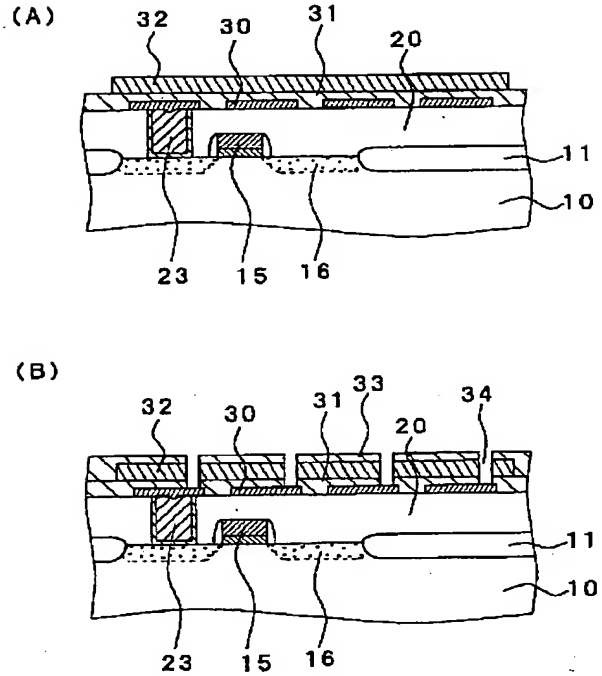
【図3】

（実施例1） その1



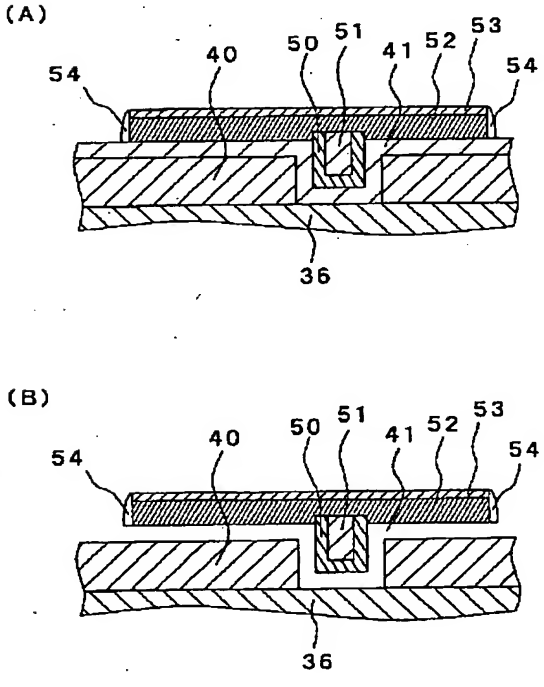
【図4】

（実施例1） その2



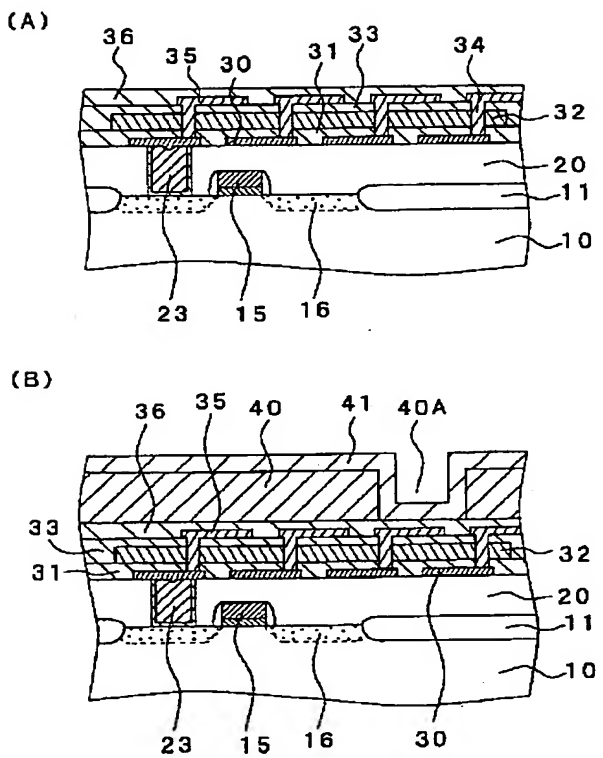
【図9】

（実施例2） その2



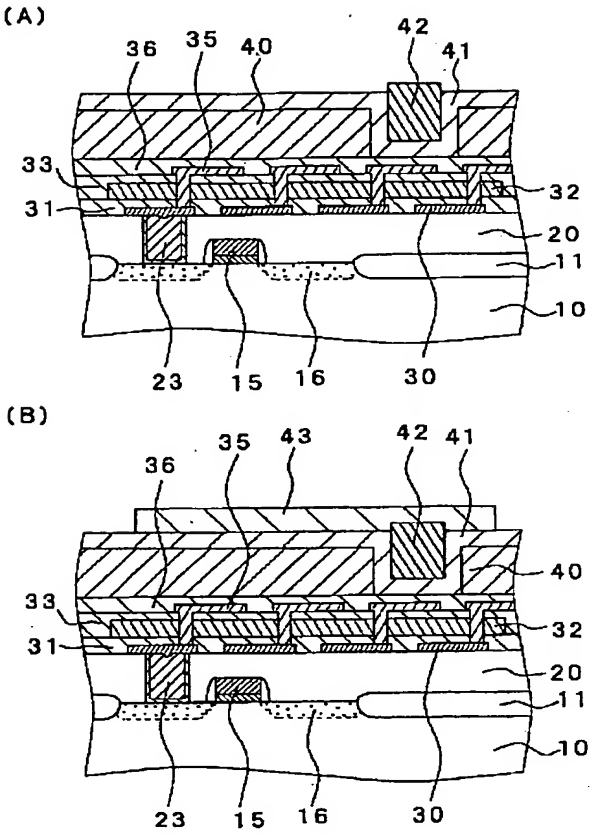
【図５】

（実施例１）　その３



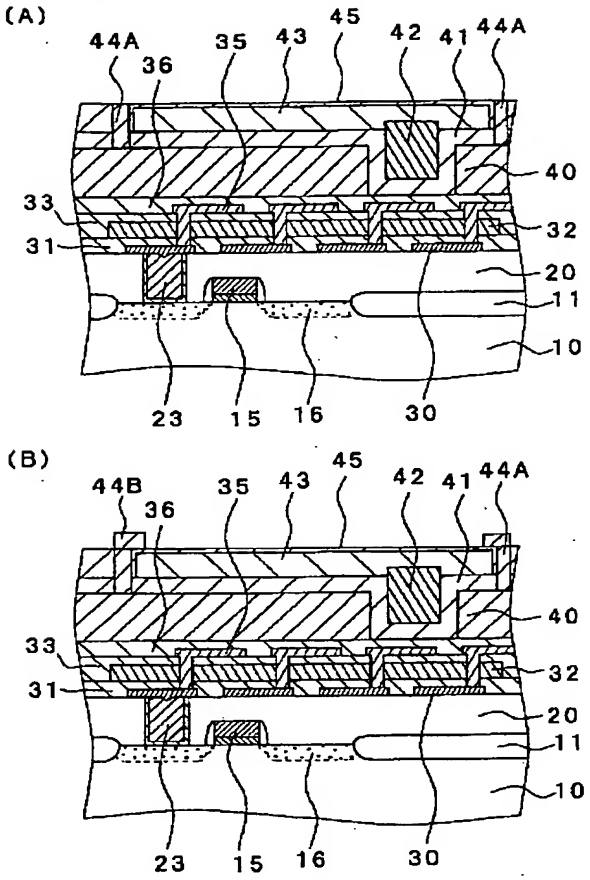
【図６】

（実施例１）　その４



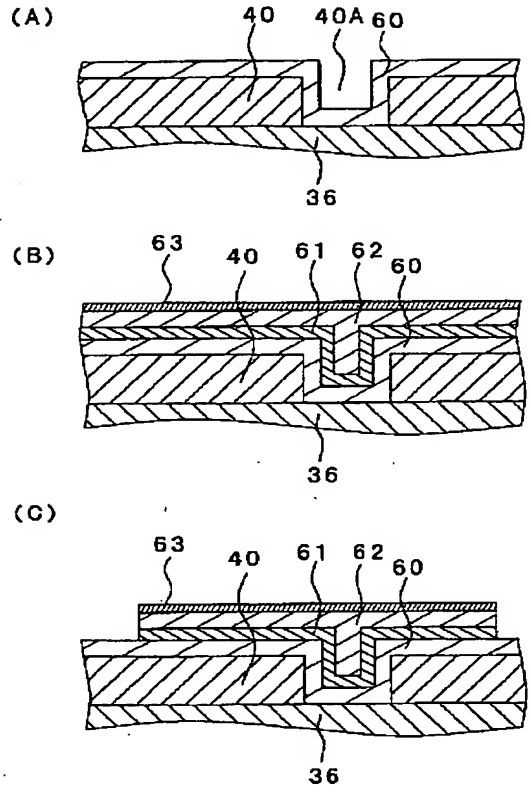
【図7】

（実施例1） その5



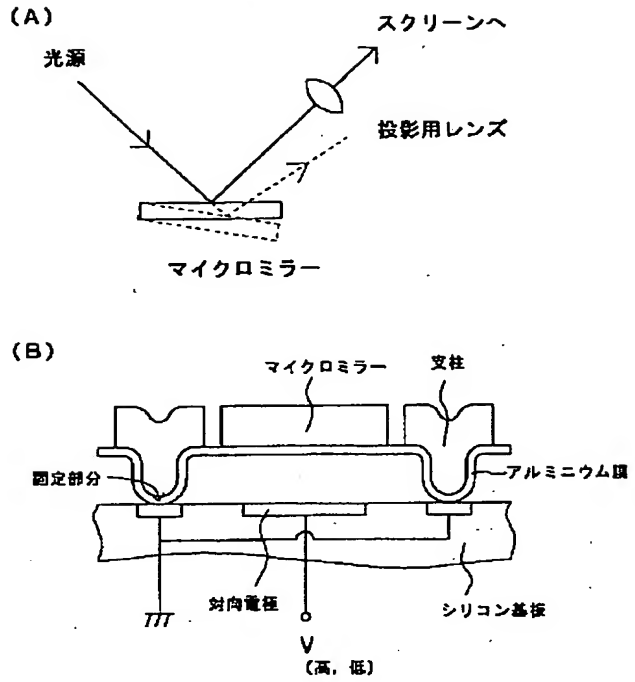
【図10】

（実施例3） その1



【図１２】

（従来の技術）


(A)
光源
スクリーンへ
投影用レンズ
マイクロミラー
(B)
マイクロミラー
支柱
固定部分
アルミニウム膜
対向電極
シリコン基板
V
(高，低)